THE

DYNAMICAL THEORY

OF THE

FORMATION OF THE EARTH.

BY

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"Through faith we understand that the worlds were framed by the Word of God; so that things which are seen were not made of things which do appear."

HEBREWS xi. 3.

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DYNAMICAL THEORY

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SECTION I.

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MANY years have elapsed since the fundamental principles of the Cosmographical Theory, whose development occupies the following pages, presented themselves to our mind.

Some of these have been passed under a tropical sky, and others in the more cloudy and sombre regions of our native land; vicissitudes of circumstances, and changes in life, and, consequent thereon, variations of mental habitudes have intervened—indeed, have intentionally been permitted to intervene—until the undeniable effects of time warn us to postpone no longer—in order that, by every possible test, we might prove the soundness of the remarkable but indestructible conclusion to which our earlier studies had led us—namely, THAT THE EARTH DID NOT ALWAYS ROTATE AROUND ITS AXIS.

In estimating the probable effect which the announcement of this truth is likely to produce on the minds of others, especially of those whose attention may not have been directed to the studies which are indispensable for due preparation, we have considered that, naturally, as much, probably much greater, reluctance will be experienced by them in admitting this truth than what we ourselves experienced when first it presented itself to our imagination—when we even shrunk from it as if it had been a monstrous lie, seeking to insinuate itself amongst the simpler and more obvious lessons which we had been taught by philosophy!

The remembrance of these impressions, and of the anxiety which we then experienced when called upon, by its importunate recurrence, to make our election—to admit it at once, or to thrust it away from us entirely—induces us, now, to be very considerate when similar prejudices arise in the minds of others; and in all our arguments, to select the evidences which we may have occasion to bring forward, so as to remove every obstacle, and to make the way clear for the reception of this important truth, and of all those others, which, as natural consequences, emanate from it; while, on the other hand, we trust that henceforward the erroneous dogma of rotation *ab initio*, with all the grievous errors into which it has led us, and has been the means of perpetuating, may be entirely swept away, never to re-appear.

Withal, we are fully aware that it is extremely difficult for the inhabitants of a world, wheeled round by its diurnal motion through space, and constrained to take this elementary motion into all their calculations, to believe that it was not always so —*that there once was a period of non-rotation.*

Those, who from the moment they open their eyes on this fair earth, perceive the light of the sun, and grow up under its cheering and fostering influences, will most reluctantly give themselves up to the persuasion that there once was a time—a period of long duration, when the central orb afforded no light, and when the earth recognised it only as the convergent centre of attraction—the great sustaining counterpoise which enabled it to revolve through unillumined space.

It is no easy task to persuade mankind, that the sparkling,

briny seas, which are now so easily excited and lashed into foam by the ambient atmosphere, were once a dark, unruffled and atmosphereless mass of turgid waters, charged to repletion with the mineral elements of those stony concretions which now engirdle the terraqueous globe, and which have been thrown up as barriers to restrain the very waters from whence they themselves were deposited.

Nor is it a less arduous undertaking to convince those who delight in the invigorating influences of the health-giving atmosphere; that, for ages, this sphere existed without so indispensable a means of sustaining voluntary motion—and that myriads of apulmonic creatures, "more numerous than the sands on the sea shore for multitudes," were all the while employed as the humble and submissive agents of the Creator, in producing one of its component elements; in elaborating *that*, without which no being, endowed with the faculty of locomotion, could either have breathed, moved, or lived.

All these, nevertheless, are truths: truths of the utmost importance. Of this, the perusal of the following treatise can hardly fail to convince every unbiased mind, even although our relative position towards the world's inhabitants involves the alternative, either that we are in a trance; have been for so many years enjoying the most soul-satisfying dream, whereby the records of revelation have appeared to be at one with the discoveries of science, and to have kept pace with these wherever they have been made, where every closed lock seems to undo, and every barred door to fly open at our approach, and on the announcement, *that there once was a period when the earth had no rotation;* or mankind, ont he contrary, have been in a profound slumber, as regards this important fact, for nearly six thousand years! This is our true relation to each other at the present moment. But it is full time that the spell should be broken, and the rightful position of each be justly determined.

With this intention, responsible as it is to stand against the arrayed opinions of a whole world, we have resolved to be the first to break this long-continued silence, and endeavour to convince all mankind, that we have all the while been entertaining no day dream; but that what we assert is a reality, and

stands upon the authority of the immutable word of God, from which, assisted by the discoveries of science, we can derive the necessary data to prove, that during the period called in Scripture "the beginning," THE EARTH HAD, IN REALITY, NO ROTATION AROUND ITS AXIS.

With respect to the scientific evidences, we here take occasion to premise—what will very soon force itself upon the reader's notice—that they are entirely derived from the writings and the researches of others: whatever merit attaches to them, belongs exclusively to their authors, not to us. We are to be regarded merely as the mind through which these matured truths have been made to pass; and by which they have been arranged, combined, and applied according as, we believe, they were designed to be, by the plan of creation; traced out from all eternity; progressively but slowly developed for many ages, but rapidly unrolled during the first six days of the Mosaic week; when the whole was finished, and made a glorious and a perfect fabric, in which even the all-searching eye of Omniscience could discover no defect, but by Him was pronounced to be "good."

The jeweller pretends neither to have *made* the orient pearls, nor to have formed or discovered the sparkling gems of which *his* work consists. Their proper selection, their arrangement, and the workmanship of studding them are alone his. So we, in like manner, disclaim all pretension to be the makers of those jewels of nature. *Natural truths*, which, like beauteous pearls, cannot be made by man; although man's industry, in either case, is required to bring the objects of his enterprize from underneath the depths to the light of day, to remove whatever conceals them, and to display them to the admiration of the beholders.

Neither do we pretend to have discovered, to have wrought up, or to have polished any of those radiant gems—*residuals of ancient organisms*—which the intelligence and assiduity of scientific naturalists have happily enabled them, in these latter days, to find; and which they have with so much skill extricated from the embedding rocks, and fitly framed together, until they have stood forth in perfect truthfulness, in all their endless variety of strange and uncouth forms; reflecting back

upon an astonished world the almost bewildering light of antiquity; of an incipient creation!

To none of these achievements do we put forth any pretension. But *we do* pretend to have discovered an ancient and a massive crown—once the glory of all—from which, by neglect, these beauteous gems and costly pearls have been allowed to fall; and to have found, besides, a casket containing abundance of fine gold and of silver seven times purified, wherewith to repair the crown, and to reset the jewels. And ever since we made these discoveries, and have become their custodier, we have wrought assiduously—have given our eyes little sleep, and our eyelids little slumber, while busied with the soul-satisfying labour of endeavouring to furbish the crown; to replace those ornaments of inestimable value which conferred upon it so much lustre; and to restore it to all its former splendour!

One after one, as we took up and handled these radiant jewels, and while we admired their beauty, we have sought anxiously and prayerfully, that we might be directed to restore it to that precise part from whence, in the lapse of ages, it had fallen; and as each jewel assumed its place, and commingling in radiance, shed a lustre on every other, and together displayed the full symmetry and beauty of the crown on which they were thus inwrought, we have at length been made to exclaim—Behold how glorious! How worthy of the great Creator, who by His wondrous wisdom and His power did frame and fashion them all at first!

Before, however, we proceed to the development of our cosmographical conceptions, or enter upon the intricacies of argument, it may be conducive to give a short summary of those principles of belief which will be found at the bottom of them all; and which, indeed, alike constitute their groundwork, and support their subsequent superstructure.

We believe, in the first place, that the Bible contains a revelation from God: and that "a revelation" is a discovery by God to man of Himself—that is, of His attributes, His works, or His will, over and above what he has been pleased to make known by the light of nature or reason.

We believe that, as no material thing is self-created, all

must possess a condition which has not emanated from materialism, and, therefore, to attain a perfect knowledge of whatever the senses make known to us, we must, after receiving all the answers which nature can give to our enquiries, appeal to a source above and beyond it. *For nature cannot answer all the questions requisite to be put to it, in order to comprehend its objects thoroughly*, and, having thus to apply to a source beyond nature, we must appeal to the Bible; *the only* revelation from God the Creator.

We believe, besides, that the Bible can afford whatever explanation is wanting, by the light of reason, for a perfect comprehension of the works of creation; that in it nothing is overlooked, nor is there in it anything redundant; and that the words of the *first* chapter of Genesis detail, in the only way in which man can be made to comprehend it, the unfolding of the plan of creation devised from all eternity; that these words embody NATURE'S CONSTITUTIONAL CODE, which it cannot fail implicitly to obey; and, therefore, to understand it thoroughly, we must become acquainted with them. We believe that whatever is mentioned in the first chapter of Genesis as having been either created, made, suspended, or changed by God, has from thenceforth become a primary, permanent cause, with no intervening cause between it and the Creator; and, therefore, all attempts to investigate the *unrelated* or *intimate* nature or composition of such, must, as a matter of course, prove entirely fruitless. That we can know only what is revealed respecting it, and acquire an intimacy with its *relative* nature in respect to other material substances around.

While, all results not directly mentioned in the first chapter of Genesis, but which are implied, are *secondary causes*, emanating themselves from primary causes, and together producing those effects which, from their persistency, are termed *natural*. And that all alike—of whatever description—originated from God the Father, God the Son, and God the Holy Spirit, "without whom was not anything made that is made."

We believe, that previous to the Mosaic week, and during the protracted period called the beginning, God did create certain substances, organic and inorganic, whose existence

(although they are not particularly described) is assumed, and clearly inferred by the inspired historian in his subsequent narrative. And, further, that during the six working days of the Mosaic week, each day consisting of twenty-four natural hours, these primary substances were wrought up, transformed, or modified by the Creator into the varied objects which now compose the material universe.

That while unfolding the numerous conceptions which have conspired to produce the most prominent dogma of this theory, namely, that during the period abovementioned, *the Earth had no rotation around its axis*, we finally believe, that scientific research has attained a state of perfection sufficient to enable us, by judiciously blending its truths with those of revelation, to produce such a system of cosmogancy as shall entirely satisfy the human mind, as shall meet all its requirements, by convincing the understanding while it invigorates our faith in the Word of God.

This desirable consummation has been all along the sole aim and design of our undertaking.

To accomplish this we have, for many years, dedicated such portions of our time and attention as could with propriety be abstracted from more ordinary labours, and such as are usually given up to recreation. We have striven, by all means in our power, to infuse into these volumes every particle of knowledge which we either possess or can by possibility acquire. In fine, we have done what we could for the cause of truth, sacred and secular. With a willing heart and a sincere intention we have laid the results of our assiduous labours at the feet of the Creator, and upon the altar of His word; and while we deeply lament that we have not had it in our power to present a more perfect or acceptable offering, we feel assured that what we do present will neither be rejected, nor will our hope be lost—for "none ever were ashamed who placed their confidence in God!" And we have, therefore, now merely to desire, that we each may be blessed in the execution of our respective duties: we, in endeavouring to make plain what we have to say; the reader, in his endeavours to comprehend, to advantage, what we shall lay before him.

The residue of this section will be dedicated to the principles upon which the Dynamical Theory is founded. The general reader will understand, that they are intended merely to be references for the elucidation of our subsequent discourse. We commence with the evidences from Scripture. They are as follow:—

"In the beginning God created the heaven and the earth.

"And the earth was without form, and void; and darkness *was* upon the face of the deep: and the Spirit of God moved upon the face of the waters." Gen. i. 1, 2.

Genesis ii. 4. xxiv. 3. 2 Kings xix. 15. 1 Chron. xvi. 26. xxix. 11. 2 Chron. ii. 12. Ezra v. 11, 12. Nehem. i. 5. ix. 6. Job x. 21, 22. xxvi. 5—7. xxxviii. 4—7. Psalm viii. 3. xxiv. 1, 2. xxxiii. 6. lxxxix. 11, 12. xcv. 3—5. xcvi. 5. cii. 25—27. civ. 5—9. cx. 1, 2. cxi. 2—7. cxv. 15. cxxiv. 8. cxlviii. 1—6. Prov. viii. 22—26. Isaiah xlii. 5. xliii. 10—15. xliv. 6. xlv. 5—7, 12, 18. xlvi. 5—9. xlviii. 1—8, 12, 13. li. 12—16. lxvi. 1, 2. Jer. x. 10—13. xxiii. 24. xxvii. 5. xxxii. 17, 27. xxxiii. 2. li. 15, 16. Lam. v. 19. Ezek. xiv. 12—21. Dan. ii. 22. Zech. xii. 1. Mark xiii. 19. John i. 1—3. Acts iv. 24. xv. 18—21. xvii. 22—26. Rom. i. 20. 1 Cor. ii. 10, 11. Col. i. 12—17. Heb. xi. 3. 2 Pet. iii. 5, 6. Rev. i. 8—11. x. 6. xiv. 7.

"And God said, Let there be light: and there was light.

"And God saw the light, that *it was* good: and God divided the light from the darkness.

"And God called the light Day, and the darkness he called Night. And the evening and the morning were the first day." Gen. i. 3—5.

Psalms lxxiv. 16. civ. 2. Isa. xlv. 7. Jer. xxxiii. 20—25. Ezek. xiv. 12—21. Dan. ii. 22. Amos iv. 13. v. 8. 2 Cor. iv. 6. Blair's Chron. Tables, copper plate edition, p. 1, Sabbath 23d October, 4004 years B. C.

"And God said, Let there be a firmament in the midst of the waters, and let it divide the waters from the waters.

"And God made the firmament, and divided the waters which *were* under the firmament from the waters which *were* above the firmament: and it was so.

"And God called the firmament Heaven. And the evening and the morning were the second day." Gen. i. 6—8.

Judges vi. 36—40. 1 Kings viii. 35. xviii. 44, 45. 2 Chron. vii. 13.

Job ix. 8. xxvi. 8, 9. xxviii. 25, 26. xxxvi. 27—29. xxxvii. 10—16. xxxviii. 8—10. Ps. viii. 3. lxxiv. 16. xcvi. 5—10. xcvii. 6. cii. 25—27. civ. 2. cxxxvi. 5, 6. cxlvii. 8. cxlviii. 3—8. Prov. viii. 27, 28. Isaiah xlii. 5. xlv. 12—18. xlviii. 13. li. 12—16. Jer. x. 11, 12. li. 15, 16. Amos iv. 13. Ezek. xiv. 12—21. Haggai i. 10. Zech. viii. 12. xii. 1. 1 Pet. iii. 5. James v. 18. Rev. x. 6.

"And God said, Let the waters under the heaven be gathered together unto one place, and let the dry *land* appear: and it was so.

"And God called the dry *land* Earth; and the gathering together of the waters called he Seas: and God saw that *it was* good." Gen. i. 9, 10.

Nehem. ix. 6. Job xxxviii. 8—11. Ps. xxxiii. 7—9. xcv. 3—5. cxxxvi. 6. Proverbs viii. 27—29. xxx. 4. Isaiah xlii. 5. xlviii. 13. Jer. v. 22. Ezek. xiv. 12—21. Hosea ii. 21—23. Amos iv. 13. Jonah i. 9. ii. 5, 6. Acts iv. 24. 2 Pet. iii. 5, 6. Rev. x. 6. xiv. 7.

"And God said, Let the earth bring forth grass, the herb yielding seed, *and* the fruit-tree yielding fruit after his kind, whose seed *is* in itself, upon the earth: and it was so.

"And the earth brought forth grass, *and* herb yielding seed after his kind, and the tree yielding fruit, whose seed *was* in itself, after his kind: and God saw that *it was* good.

"And the evening and the morning were the third day." Gen. i. 11—13.

Gen. ii. 5—9. 1 Kings iv. 33. Ps. lxxiv. 16. cxlvii. 8. cxlviii. 9. Isa. xlii. 5. lv. 10. Zech. viii. 12. Heb. vi. 7. Rev. x. 6.

"And God said, Let there be lights in the firmament of the heaven, to divide the day from the night; and let them be for signs, and for seasons, and for days, and years:

"And let them be for lights in the firmament of the heaven, to give light upon the earth: and it was so.

"And God made two great lights; the greater light to rule the day, and the lesser light to rule the night: *he made* the stars also.

"And God set them in the firmament of the heaven, to give light upon the earth,

"And to rule over the day and over the night, and to

divide the light from the darkness: and God saw that *it was* good.

"And the evening and the morning were the fourth day." Gen. i. 14—19.

Gen. viii. 22. xv. 5. Job ix. 8. xxxviii. 31—33. Ps. viii. 3. xix. 1—6. lxxiv. 16, 17. civ. 19. cxxxvi. 7—9. cxlvii. 4. cxlviii. 3—5. Isa. xxxviii. 7, 8. xlv. 12. Jer. xxxi. 35, 36. Ezek. xxxii. 7, 8. Joel iii. 15. Amos v. 8. Rev. x. 6.

"And God said, Let the waters bring forth abundantly the moving creature that hath life, and fowl *that* may fly above the earth in the open firmament of heaven.

"And God created great whales, and every living creature that moveth, which the waters brought forth abundantly, after their kind, and every winged fowl after his kind: and God saw that *it was* good.

"And God blessed them, saying, Be fruitful, and multiply, and fill the waters in the seas; and let fowl multiply in the earth.

"And the evening and the morning were the fifth day." Gen. i. 20—23.

Gen. viii. 17. ix. 1—17. 1 Kings iv. 33. Job xli. 1—34. Ps. l. 10, 11. lxxiv. 16, 17. civ. 25, 26. cxlvi. 6. cxlviii. 7. Ezek. xiv. 12—21. Rev. x. 6.

"And God said, Let the earth bring forth the living creature after his kind, cattle and creeping thing, and beast of the earth after his kind: and it was so.

"And God made the beast of the earth after his kind, and cattle after their kind, and every thing that creepeth upon the earth after his kind: and God saw that *it was* good." Gen. i. 24, 25.

Gen. ii. 19. vi. 6, 7. vii. 21. viii. 1—3, 20—24. ix. 1—17. Job xxxix. 1—30. xl. 15—24. Ps. l. 10, 11. cxlviii. 10. Jer. xxvii. 5. xxxii. 27.

"And God said, Let us make man in our image, after our likeness; and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all

the earth, and over every creeping thing that creepeth upon the earth.

"So, God created man in his *own* image; in the image of God created he him; male and female created he them.

"And God blessed them; and God said unto them, Be fruitful, and multiply, and replenish the earth, and subdue it; and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth." Gen. i. 26—28.

Gen. ii. 7—17. iii. 12, 13, 20. v. 1, 2. vi. 6, 7. ix. 1—17. Deut. xxxvii. 18. Job iv. 17. x. 8, 9. Ps. vii. 6—8. c. 3. cxlviii. 11—13. Prov. xiv. 31. Eccles. xii. 7. Isa. xvii. 7. xlii. 5. xlv. 9—11. liv. 5. Jer. xxvii. 5. xxxii. 7. Dan. v. 21—25. Hosea viii. 14. Zech. xii. 1. Mal. ii. 10. Mark x. 6. Luke iii. 38. Acts iii. 27. iv. 24. vii. 20—50. xiv. 15. xvii. 22—27. 1 Cor. xv. 45—47. Ephes. iv. 3—6. 1 Tim. ii. 13. James iii. 9. 1 Pet. i. 17—20. 2 Pet. i. 17, 18. 1 John 1—4. Rev. x. 6. Blair's Chron. Tables, p. 1, Friday, 28th Oct., 4004 B. C.

"And God said, Behold, I have given you every herb bearing seed, which *is* upon the face of all the earth, and every tree, in the which *is* the fruit of a tree yielding seed; to you it shall be for meat.

"And to every beast of the earth, and to every fowl of the air, and to every thing that creepeth upon the earth, wherein *there is* life, *I have given* every green herb for meat: and it was so.

"And God saw every thing that he had made, and, behold, *it was* very good. And the evening and the morning were the sixth day.

"Thus the heavens and the earth were finished, and all the host of them.

"And on the seventh day God ended his work which he had made; and he rested on the seventh day from all his work which he had made.

"And God blessed the seventh day, and sanctified it; because that in it he had rested from all his work which God created and made." Gen. i. 29—31. ii. 1—3.

Gen. ii. 4, 5. ix. 1—17. xiv. 22. xviii. 25. Exod. xx. 11. Deut. v. 12—14. 2 Kings xix. 15. 1 Chron. xvi. 26. 2 Chron. ii. 12. Ezra v. 11, 12. Job xii. 10. xxxviii. 1—11. Ps. xxiv. 1, 2. xxxiii. 9. xc. 1—4. xcv. 15. xcix. 6. ciii. 7. civ. 13—24. cxv. 15. cxix. 89—91.

cxxiv. 8. cxlvi. 5, 6. cxlvii. 1—9. Prov. xvi. 4. xxii. 2. xxvi. 10. xxx. 4, 5. Eccles. iii. 11—15. viii. 17. xi. 5. Isa. vi. 3. xxxvii. 16. xl. 12—14, 28. Ezek. xiv. 12—21. Matt. xii. 8. xvii. 3, 4. Mark ii. 27, 28. ix. 4, 5. Luke ix. 30. xvi. 31. John v. 45—47. Acts iii. 22. vi. 11—14. vii. 20—33. xvii. 22—29. 1 Cor. x. 26. 2 Cor. iii. 7—13. Ephes. iii. 9—11. Colos. i. 12—17. Heb. iii. 1—6. iv. 4. Jude i. 9. Rev. i. 8—11. iv. 11. x. 6. Rev. xv. 3. xix. 5—16.

THEOREMS.

1. That the EARTH is a spheroid of rotation, whose equatorial exceeds its polar diameter about twenty-six miles, the former being 7,925, the latter 7,899 miles. That the oblateness of this ellipsoid deduced from actual measurement, although somewhat less than mathematicians affirm it should be, from calculations based on its dimensions, time of rotation, component materials, law of gravity, and centrifugal force, nevertheless corresponds as nearly as the data for calculation will admit. And that a sphere contains the greatest volume of all bodies of equal surface.

Astronomy, by Sir John Herschel, new edit. Cab. Cyc. pp. 117, 121, 122. System of Astronomy, by Margaret Bryan, 1797, pp. 27, 69. Geology, by H. de la Beche, p. 1. Whitehurst's Theory, pp. 3—15 (difference between diametres 36 miles). Mechanics, Cab. Cyc. pp. 24, 157, 158. Geology, by M'Culloch, vol. i. pp. 16—18. Huttonian Theory, by Playfair, pp. 448—504. Watts on the Ellepticity of the Earth, Edin. Phil. Jour. No. VI. pp. 288—293. Encyclopedeæ Metropolitana, by Prof. Airey. Mrs. Somerville on the Connection of the Sciences, pp. 8, 48, 58—63, 410. Edin. Jour. Nat. Hist. p. 28. Prof. Buckland's Bridg. Treat. vol. i. pp. 39, 40. Phillips's Geology, p. 7. Heat, in Cab. Cyc. pp. 195, 196. Disc. on Nat. Philos. by Sir John Herschel, p. 98. De Luc's Letters, p. 71, 72. Meteorology, by Dr. Thomson, 1849, Introduction.

2. That the EARTH is a non-luminous body, receiving its external light and heat from the sun. And that the heat received is a fixed quantity, subject to the following invariable law, namely, "that the momentary supply varies in the exact proportion of the angular velocity, i. e., of the momentary increase of longitude;" from which it follows, that equal amounts of heat are received from the sun in passing over equal angles

round it, in whatever part of the ellipse these angles may be situated.

Astronomy, Cab. Cyc., by Sir John Herschel, new edit. pp. 10, 194, 198, 211, 212. Heat, Cab. Cyc. pp. 350, 382. Optics, by Sir D. Brewster, Cab. Cyc. p. 2. Mrs. Somerville on the Connection of Sciences, pp. 11, 19, 82, 85, 86, 254, 265, 277. Geology, by H. T. de la Beche, p. 5. Prof. Whewell's Bridg. Treat. pp. 76—79, 169—172. Chemistry, in Cab. Cyc. p. 91. Daniel's Philos. of Chemistry, pp. 164—166. Phenomena and Order of the Solar System, Dr. Nichols. System of the World, by M. Lambert. Meteorology, by Dr. Thomson, 1849, p. 36, et seq.

3. That the EARTH has a double movement in space; one by which it revolves around its own axis in 24 hours solar time, or in 23 hours 56′ 4.09″ sideral time, and another movement whereby it performs its periodical revolution, in an invariable plane, around the sun, in what is termed the tropical year, of 365 days 5 hours 48′ 49″·7. That these two motions are entirely independent of each other. And that if the Earth did receive its double movement from a single impulse, it is considered, by computation, that the impulse must have passed through a point about twenty-five miles from its centre.

Astronomy, Cab. Cyc. by Sir John Herschel, new edit. pp. 74, 205, 206. System of Astronomy, by Margaret Bryan, 1797, pp. 191—205. Mrs. Somerville on the Sciences, pp. 9, 10, 71, 75, 81—83, 88, 93, 419, 438. Prof. Whewell's Bridg. Treat. pp. 14, 33, 34, 145.

4. That the orbital revolutions of the EARTH and other planets around the sun, almost in the plane of its equator, and of the satellites around their primaries, are caused by the combination of the sun and the planets' mutual attraction, and an original projectile impulse; whilst the whole system is connected and regulated by the law, of the squares of their periodical times being proportional to the cubes of their mean distances from the sun. That the same laws maintain the comets in their more elliptical orbits, *their* eccentricity depending wholly on the direction and force of the original impulse which put *them* in motion.

Mechanics, Cab. Cyc. pp. 80, 127. Astronomy, by Sir John Herschel, Cab. Cyc. pp. 232—235, 269. System of Astronomy, by Margaret

Bryan, 1797, pp. 191—205. Mrs. Somerville on the Sciences, pp. 6, 9—11, 15, 16, 379, 423. Prof. Whewell's Bridg. Treat. pp. 151, 157. Nat. Philos. Cab. Cyc. by Sir John Herschel, pp. 272, 273. Mechanism of the Heavens, by Dr. Nichols, Edin. 1837. Phen. and Order of the Solar System, by Dr. Nichols, pp. 108—124. System of the World, by M. Lambert.

5. That the EARTH and other planets have their axis inclined at various degrees of obliquity to the plane of their respective orbits, and that these latter are at different degrees of obliquity to the ecliptic. That the sun, and such of the planets as afford sufficient data for astronomical calculations, are known to have rotatory motion; *that* of the sun being performed in days 25.01154, whilst it also describes a small irregular orbit about the centre of gravity of the system. And that the mean density of the sun is computed to be to that of the earth as 0.2543 is to 1.0.

Astronomy, by Sir John Herschel, Cab. Cyc. pp. 192—195, 209, 240, 243—287, 416. System of Astronomy, by Margaret Bryan, 1797, p. 252, et seq. Ferguson's Astronomy, vol. v. p. 17. Mrs. Somerville on the Sciences, pp. 12—14, 27—29, 76, 184. Geology, by H. T. de la Beche, p. 6. Prof. Whewell's Bridg. Treat. pp. 14, 165, 166. Architecture of the Heavens, Nichols, pp. 175—177. Phen. and Order of the Solar System, pp. 70, 126, 136, 142, 177, et seq. System of the World, by M. Lambert, p. 37, et seq.

6. That the vicissitude of seasons experienced by the EARTH is owing to its globular form, the obliquity of the plane of the equator to that of the ecliptic, the parallelism of the earth's axis, and to the orbital motion of the earth around an illumined sun imparting light and heat.

Astronomy, by Sir John Herschel, Cab. Cyc. pp. 194—266. System of Astronomy, by Margaret Bryan, pp. 252—282. Mrs. Somerville on the Sciences, pp. 27, 28, 85, 100. Prof. Whewell's Bridg. Treat. p. 17. Mechanics, Cab. Cyc. p. 14. Phen. and Order of the Solar System, pp. 31, 32, 42, 63—65. System of the World, by M. Lambert. Meteorology, by Dr. Thomson, 1849, pp. xx.—xxiii.

7. That owing to a secular motion in the position of the major axis of the solar ellipse, arising from a direct motion of the perigee and the retrogradation of the node of the earth's equator on the ecliptic (called the precession of the equinoxes), which conjointly accomplish an entire revolution in 20.984

years, a corresponding, gradual, but entire change is going on in the relative positions of the major axis and the line of the equinoxes; which, about 4,000 years before the Christian era, coincided with each other.

And that this secular change is the necessary consequence of the rotation of the earth and the disturbing action of the sun and moon on the redundant matter accumulated about the earth's equator.

Astronomy, by Sir John Herschel, pp. 170—173, 313—334. Geology, by Dr. John Ure, pp. 13, 14. Prof. Playfair's Works, vol. ii. pp. 411—413, vol. iv. pp. 305—307. System of Astronomy, by Margaret Bryan, 1797, pp. 96, 256. Mrs. Somerville on the Sciences, pp. 21—25, 32—36, 62—76, 91—94, 99, 161—166, 309, 438, 439. Heat, Cab. Cyc. p. 195. Nat Philos. by Sir John Herschel, pp. 273, 276, 277.

8. That about three-fourths of the earth's surface is covered by the ocean; and, therefore, the aqueous is to the terrestrial surface as 3 is to 1. That the mean depth of the ocean has been variously estimated, the least being from three to four miles, the greatest from four to five miles. That the mean specific gravity of the earth's outer crust is to that of the aqueous portion as 5 is to 2, whilst its entire mean density is considered to be five times that of water.

Any Treatise on Geography. Geology, by H. T. de la Beche, pp. 2—5. Dr. Young's Lectures, p. 47. Laplace's System, vol. ii. p. 116. Meteorology, supplement, Ency. Britan. Espy on the Philosophy of Storms, 1841. Astronomy, by Sir John Herschel, pp. 22, 23. Prof. Playfair's Works, vol iii. pp. 438, 439, iv. p. 302. Dick's Christian Phil. p. 60. Prof. Whewell's Bridg. Treat. p. 52. Mrs. Somerville on the Sciences, pp. 63, 89, 106. Geology, by Dr. M'Culloch, vol. i. pp. 21, 32. Prof. Buckland's Bridg. Treat. vol. i. p. 55. Phillips's Geol. pp. 8, 9, 22, 23, 277—282. Edin. New Philos. Jour. vol. viii. 1827. Mechanics, by Laplace, Toplis, pp. 260—266, et seq. Phen. and Ord. of Solar System, p. 142, et seq. Meteorology, by Dr. Thomson, 1849, p. xix.

9. That the Moon—a non-luminous satellite 2,160 miles in diameter—receives its heat from the sun, its light from the sun and earth; has a triple revolution in space: one by which it accompanies its primary around the sun, and a binary movement (performed by the same motion in 27 days 7 hrs. 43′ 11″), consisting of its siderial path around the earth, and rotation around its axis. That owing to this double revolution by a

single movement, together with its libration, and *slight* obliquity of axis, the same hemisphere, increased by a narrow zone occasionally seen on either side, presents itself invariably towards the earth.

And that no indications of either continents or oceans present themselves on its earthward disc, although it affords manifestations of being extremely mountainous, the elevations *appearing* to have originated from volcanoes, now extinct.

Astronomy, by Sir John Herschel, Cab. Cyc. System of Astronomy, by Margaret Bryan, 1797, pp. 272—282, 293—298. Connexion of the Sciences, pp. 69—80. Phen. and Order of the Solar System, pp. 149—173. Meteorology, by Dr. Thomson, 1849, p. 337.

10. That according to investigations made by M. de Laplace, for the purpose of determining the stability of the equilibrium of the sea, it has been discovered,

"That the equilibrium of the sea must be stable, and its oscillations continually tending to diminish if the density of its waters be less than the mean density of the earth; and that its equilibrium would not admit of subversion unless the mean density of the earth was equal to that of water or less."

Prof. Playfair's Review of Laplace, vol. iv. p. 304. Mrs. Somerville on the Sciences, pp. 56, 114. Prof. Whewell's Bridg. Treat. pp. 177—180. Astronomy, by Sir John Herschel, Cab. Cyc. Phillips's Geol. pp. 22, 277, 282. Mechanics, by Laplace, Toplis, pp. 244—270.

11. That on taking a general view of the great geographical outlines of the world it is seen to be divided, in directions nearly parallel to its axis of rotation, into three great continental ridges, namely, that of North and South America, with the intervening archipelago. 2nd, Europe and Africa; and 3rd, Asia and New Holland, with the Polynesia, which intervene.

That there is a remarkable similitude in the general contour of these three great divisions, especially between the first and the last, seeming to indicate that their form is due to a common cause. And that within the equatorial zone are situated the most extensive table lands, and the greatest number of islands.

Any map of the world.

12. That the continents, and even the islands, are found to possess a flora of species peculiarly their own. That whilst a considerable number of plants are common to the Northern regions of Asia, Europe, and America, where these continents almost unite, towards the south, where they widely diverge, the floras of these three great divisions of the globe differ very materially, even in the same parallels of latitude.

And that, upon the principle of distinct floral foci of creation, the whole earth has been divided, by botanists, into a certain number of botanical districts, differing from each other almost entirely in their specific vegetation.

Botany, by Prof. Henslow, Cab. Cyc. pp. 294—309. Lyell's Principles of Geol. vol. ii. pp. 69—75, 131. Mrs. Somerville on the Sciences, pp. 278—285. Lyell's Elements of Geol. vol. ii. p. 68. Old Red Sandstone, by Miller, pp. 196—198.

13. That wherever any considerable portion of the Earth's surface has been examined by geologists, it has invariably afforded proofs of having been, at one time, submerged in the waters of the ocean.

Lyell's Principles of Geology, vol. i. pp. 49, 51, 146, 153, 155. vol. ii. pp. 312—318, and map. vol. iii. pp. 9, 23, 126, 130—135, 150, 151, 213, 239, 240, 330, 331. Whitehurst's Theory of the Earth, p. 15, et seq. Playfair's Huttonian Theory, pp. 1, 4—6, 40, 144, 145. Laplace's System, vol. ii. p. 116. Werner on Veins, p. 110. Turner's Sacred History. Manual of Geology, by H. T. de la Beche. Jamieson's Illust. of the Cuvierian Theory, pp. 297, 298. Edin. Phil. Jour. No. xv. pp. 116, 117. Dr. Fleming's Letter, xvii. pp. 226—230. Nat. Phil. by Sir J. Herschel, Cab. Cyc. pp. 144, 283. Edin. Jour. Nat. History, pp. 67, 68. Bakewell's Introduction to Geol. and any other similar work. Geology, by Dr. M'Culloch, vol. i. pp. 299—334. vol. ii. p. 360. Ancient World, by D. T. Ansted, pp. 5, 6. Old Red Sandstone, by Miller, Edin. Phillips's Treat. on Geology, pp. 45, 47, 48, 51—56, 166, 190—200, 259, 276—295. Lyell's Elem. of Geology, vol. i. pp. 10, 72—77, 147, 181—191. Connexion of the Sciences, p. 87. De Luc's Letters, pp. 9, 20, 29—33, 41, 127, and throughout.

14. That the stratified rocks afford sufficient evidence of having been formed in succession, horizontally and tranquilly by deposition from water, although, in many instances, bearing marks of the water having been gently undulated.[1] That they differ in many respects from the primary amorphous masses.[2]

And that the series of the strata is usually found to be constant, "the order in which they succeed one another, when present altogether, being never reversed.[3]

[1] Playfair's Huttonian Theory, pp. 4, 21, 42—46, 144, 145, 231, 235. Whitehurst's Theory of the Earth, pp. 15, et seq. espec. 129. Werner on Veins, pp. 10, 11. Edin. Philos. Jour. No. xvi. p. 227. Bakewell's Intro. to Geology. Hist. of British Animals, p. 16. Lyell's Principles of Geology, vol. i. pp. 82, 99, 159. vol. iii. pp. 2, 6, 8, 35, 213, 255, 365. Geology, by H. T. de la Beche. Jamieson on Cuvier. Theory, p. 297. Cuvier's Eloge. of Werner. Nat. Philos. by Sir J. Herschel, p. 284. Connex. of the Sciences, pp. 62, 63, 89. M'Culloch's Geology, vol. i. pp. 12, 67, 463. Prof. Buckland's Bridg. Treat. vol. i. pp. 17, 36, 44. Lyell's Elements of Geol. vol. i. pp. 10, 22, 32—34, 41, 146, 191. vol. ii. p. 388, et seq. Athenæum, No. 985, p. 935. Vindiciæ Geologici, pp. 11, 29. Phillips's Geol. pp. 32, 42, 57, 95, 154, 259, 292. De Luc's Letters, pp. 4, 30, 55—65. New Walks in an Old Field, Miller, Edin. 1841. Ancient World, by Ansted, 1847, p. 122, et seq.

[2] Geology, by H. T. de la Beche, pp. 420, 491, 492, 508. Humboldt's Superposition, pp. 13, 14. Cuvierian Theory, p. 298. Lyell's Prin. of Geology, vol. i. p. 201. vol. ii. pp. 9, 14, and Gloss. p. 79. Geol. by M'Culloch, vol. i. p. 463. Ancient World, Ansted, 1847, p. 6, et seq.

[3] Phillips's Treat. on Geol. pp. 33—37, 41, 42. Ancient World, by Ansted. Whitehurst's Theory of the Earth, pp. 177—179.

15. That when the stratified masses are examined in their order of superposition, they are frequently found to blend with each other in mineralogical character. And when traced continuously to any distance, in a horizontal direction, are found to "thin out" and run into each other, with an almost imperceptible line of junction.

Baron Humboldt on Superposition, pp. 41, 42, 465, 477. Lyell's Prin. of Geol. vol. iii. pp. 8, 14, 38, 375. Geol. by H. T. de la Beche, pp. 262, 404, et seq. Playfair's Huttonian Theory, pp. 83, 84. Geology, by M'Culloch, vol. i. p. 68. vol. ii. p. 217. Prof. Buckland's Bridg. Treat. vol. i. p. 38, 39. Ancient World, by Ansted, p. 76, et seq. Lyell's Elem. of Geol. vol. i. pp. 6, 27—39, 198, 208. vol. ii. pp. 74, 108. Phillips's Geology, pp. 40, 59. Old Red Sandstone, by H. Miller, Edin.

16. That, with the exception of some of the inferior, the stratified rocks contain innumerable vestiges of vegetable, zoophytic, and animal existences, some of which are of gigantic dimensions in comparison with recent equivalents.[1]

That there appear to have been successive creations in each of these divisions of animal, vegetable, and zoophytic life.[2]

And that they have by their exuviæ contributed largely to the formation of the carboniferous and calcareous strata.

The calcareous matter increasing in an ascending series, is yet found to be during every epoch precisely similar in its component elements.[3]

[1] Humboldt on Superposition, pp. 50, 211, 265, 307, 387. Jamieson's Cuvierian Theory, pp. 336—355. Geol. by H. T. de la Beche. Consolidated List of Fossil Remains. Playfair's Huttonian Theory, pp. 59, 147. Nat. Phil. by Sir John Herschel, p. 283. Edin. Jour. Nat. Hist. No. ii. p. 58. Turner's Sacred Hist. Botany, by Professor Henslow, p. 311. Whitehurst's Theory of the Earth, 1786, p. 29, et seq. Lyell's Prin. of Geol. vol. i. pp. 2, 105, 115, 168. vol. iii. p. 327. New Walks in an Old Field, Edin. 1841. Ancient World, by Ansted, 1847. Phillips's Intro. to Geol. p. 49, et seq. Lyell's Elements of Geol. vol. i. pp. 8, 61—67, 199—201, 294. De Luc's Letters.

[2] Geology, by H. T. de la Beche. Whitehurst's Theory of the Earth, 1786, pp. 44—49. Humboldt on Superposition, p. 50, et seq. 211, 287, 350, 391, 402. Playfair's Hutt. Theory, p. 163, 164. Hist. of British Animals, p. xv. Bakewell's Introduction to Geol. Jamieson's Cuvierian Theory, pp. 336—355. Dr. Fleming's Hist. of Zoology, vol. i. p. 26. Edin. Phil. Jour. No. xvi. pp. 226—230. Turner's Sacred Hist. New Walks in an Old Field, Miller, Edin. 1841. Lyell's Prin. of Geol. throughout. Nat. Philos. by Sir John Herschel, p. 283. M'Culloch's Geol. vol. ii. p. 415. Buckland's Bridg. Treat. vol. i. pp. 6, 62, 116, 295, 334, 417. Ancient World, by Ansted, London, 1847. Phillips's Geol. pp. 49, 51, 88. Vindiciæ Geol. pp. 8, 30. Lyell's Elements of Geol. vol. i. pp. 45, 181, 391, 408. vol. ii. 46, 153, 243, 435.

[3] Lamark on Microscopic Molusca, vide Milloilites. Playfair's Huttonian Theory, pp. 5, 144. De la Beche's Geology, pp. 205, et seq. Lyell's Prin. of Geol. vol. i. pp. 2, 115. vol. ii. pp. 111, 307, 310. vol. iii. pp. 47, 163, 239. Dr. Fleming's Phil. of Zoology, vol. i. p. 26. M'Culloch's Geol. vol. i. p. 12. vol. ii. pp. 57, 207, 262, 414. Buckland's Bridg. Treat. vol. i. pp. 62, 112. Ancient World, by Ansted, London, 1847, p. 54, et seq. Phillips's Geol. pp. 88, 117. De Luc's Letters throughout, especially pp. 53—56, 127.

17. That from the evidence afforded by the position and dislocation of the stratified masses, it is considered that they have been elevated from where they were originally deposited into the inclined positions they now occupy, and by the agency of a force which acted from below upwards.

And that the time occupied in their elevation was very brief comparatively with that which elapsed during their formation.

Prof. Playfair's Huttonian Theory, p. 40. et seq. 219. Geology of

England, by Smith, Edin. Review, No. lviii. p. 318. Bakewell's Intro. to Geol. Geol. by H. T. de la Beche, pp. 24, et seq. Whitehurst's Theory of the Earth, pp. 115—130. Humboldt on Superposition, p. 69. Connexion of the Sciences, p. 89. Lyell's Prin. of Geol. vol. i. pp. 102, 156, 456. vol. iii. pp. 8, 105, 148—151, 180, 195, 284—307, et seq. Geol. by Dr. M'Culloch, vol. i. pp. 88, 126. Prof. Buckland's Bridg. Treat. vol. ii. pp. 3, 541. Phillips's Geol. pp. 59—62, 140, 187, 210, 260, 262—276, 280. Lyell's Elem. of Geol. vol. i. pp. 94—96, 101, 146, 296. vol. ii. pp. 14, 20, 22, 356, 362. New Walks in an Old Field, Miller, 1841. Vindiciæ Geol. p. 11. Disc. on Nat. Philos. by Sir J. Herschel, p. 284. De Luc's Letters, 1st and 2nd. Ancient World, Ansted, 1847, p. 106, et seq.

18. That in contrasting the secondary with the tertiary formations, a marked difference is observable in many respects between them; the former being generally more continuous in their series and more equal in mineralogical character than the latter, and especially than their more recent portions, which are found situated in detached basins surrounded by primary and secondary formations, in very many instances without either being deranged or altered by them.

Geol. of England, by Smith, Edin. Review, No. lviii. p. 318. Lyell's Prin. of Geol. vol. i. p. 155. vol. ii. 313. vol. iii. pp. 15, 23, 229, 289, 296, 303, 309, 320, et seq. Geol. by H. T. de la Beche, pp. 192, 193, 197—199. Geol. by Dr. M'Culloch, vol. i. pp. 313, 324, 478. Prof. Buckland's Bridg. Treat. vol. i. pp. 77, 527. Ancient World, by Ansted, pp. 6—23, 73, 265, 266. Phillips's Geol. pp. 43—62, and diagram, and pp. 161—178. Lyell's Elements of Geol. vol. i. pp. 31, 270, 284, 327—330, 381. vol. ii. pp. 34, 313, 334, 348, 365. Botany, in Cab. Cyc. pp. 311—314.

19. That the state of perfect preservation in which the fossil remains of plants and shells are frequently found affords conclusive evidence that, in such instances, they grew and lived not far from where they are now found embedded. And that none of the plants belonging to the coal formations have been recognised as being of marine origin.

Botany, by Prof. Henslow, Cab. Cyc. p. 311. Geol. by H. T. de la Beche, p. 439, et seq. Whitehurst's Theory of the Earth, 1786, p. 59, et seq. esp. 121. Lyell's Geol. vol. i. pp. 27, 117, 118. Philos. of Zoology, by Dr. Fleming, vol. ii. p. 88. Turner's Sacred History. Writings of M. Ad. Brougniart on Fossil Vegetation. New Walks in an Old Field, Miller, 1841. Connexion of the Sciences, p. 85. Geol. by Dr. M'Culloch, vol. i. pp. 437, 438. vol. ii. p. 359. Dr. Buck-

land's Bridg. Treat. vol. i. pp. 16, 17, 634. Ancient World, by Ansted, London, 1847. Lyell's Elements of Geol. vol. ii. pp. 106—120, 128—130, 133—135. Phillips's Geol. pp. 47, 54, 107, 118. De Luc's Letters generally, but esp. 2nd Letter, pp. 56—58.

20. That considering the granitic, trappean, serpentinous and other rocks of similar origin to have been injected amongst the stratified masses; and that evidence still remains of great heat having been present when and where these protrusions took place—shown as well by the structure of the igneous injections themselves as by the fused, altered, rent condition, and slaty cleavage of the rocks contiguous to them—it is, likewise, considered that the extent of the alteration and the insensible transition of the altered mass, are in direct proportion to the volume of that which has been injected.

Playfair's Huttonian Theory, pp. 21—33, 54, 63, 84, 89, 182—190, 247. Humboldt on Superposition, p. 46. Werner on Veins, pp. 122, 124—126. Whitehurst's Theory of the Earth. Geology, by H. T. de la Beche, pp. 24, 486—489, 491—495, 506, 510, 575, et seq. Edinburgh Review, No. lxxiii. p. 243, Art. Trans. Camd. Soc. Lyell's Prin. of Geol. vol. iii. pp. 12, 79, 108, 367—373, 374. M'Culloch's Geol. vol. i. pp. 126—128. vol. ii. pp. 98, 127, 208. Prof. Buckland's Bridg. Treat. vol i. p. 55. vol. ii. p. 9. Ancient World, by Ansted, pp. 6—32, et seq. Lyell's Elements of Geol. vol. i. pp. 13—18, 191. vol. ii. pp. 214—226, 241, 255—263, 264—292, 300—305, 350, 401—434. Phillips's Geol. pp. 44, 61, 75, 82, 90, 110, 140, 231—239. Old Red Sandstone, by Miller, Edin.

21. That all geologists make use of terms indicating that their discourses have reference to an "external crust," "outer coating," or as it is sometimes called, "shell" of the earth, but generally without explaining to what depth these are considered to penetrate into the *viscera terræ*: yet, sufficient has been said to show that these expressions are considered to refer to that which has limits not far from the surface; and, even, in a few instances, an attempt has been made to draw a clear line of separation, at no great depth below the surface, between the solid crust and the supposed internal masses.

MSS. by M. Elie de Beaumont, as given by M. de la Beche, pp. 2, 518. Astron. by Sir John Herschel, pp. 22, 23. Nat. Philos. by the same, Cab. Cyc. p. 288. Geol. by Dr. M'Culloch, vol. i. pp. 94—97. Connexion of the Sciences, pp. 90, 260. Lyell's Prin. of Geol. vol. iii. p. 8.

defined at p. 68, Append. New Walks in an Old Field, Miller, 1841. Chemistry, by Hugo Reid, p. 140, defined. Brook's Chrystallography, Intro. p. i. Prof. Buckland's Bridg. Treat. vol. i. pp. 37, 38. Ancient World, by Ansted, 1847, p. 15, et seq. Lyell's Elements of Geol. vol. i. pp. 1—3, 191. vol. ii. 141, 192, 349, 354—369. Phillips's Geol. pp. 5, 69—78, 108, 250—258. Vindiciæ Geol. p. 29. De Luc's Letters, pp. 104—108.

22. That thick and extensive beds of breccia and conglomerate, in which the fragments are generally united by calcareous and other mineral substances, are found to intervene amongst the various series of the older and the secondary stratified masses, especially in the vicinity of mountain chains, and above and below the coal formations.

Playfair's Huttonian Theory, pp. 5, 45, 51, 209—211. Lyell's Prin. of Geol. Append. vol. iii. p. 64. Geol. by H. T. de la Beche, pp. 214—219, 323, 329, 400—403, 405—408, 491. Jamieson's Illust. of Cuvierian Theory, p. 301. Humboldt on Superposition, pp. 269, 276—278. Geol. by Dr. M'Culloch, vol. i. pp. 89, 226, 459, 464. vol. ii. pp. 222—224. New Walks in an Old Field, Miller, 1841. Lyell's Elements of Geol. vol. i. pp. 7, 76, 101, 365. vol. ii. pp. 148, 298, 356, 370. Vindiciæ Geol. p. 29. De Luc's Letters, pp. 66, 67. Phillips's Geol. pp. 92, 104, 115, 126, 293.

23. That although a diversity of opinion prevails among geologists as to the origin, classification, and the nomenclature by which the greater groups of rocks composing the earth's outer surface are to be designated; nevertheless, an accordance has been come to as regards the unstratified amorphous masses in contradistinction to all the stratified ones of every denomination.[1]

That they also concur in considering the primary rocks, besides being deficient in organic remains, to be more compact and crystalline in texture than the others,[2] and generally more elevated in their positions.[3] That they appear, in very many instances, to have been thrust up from beneath the strata, raising these up also, whether they have perforated or not wholly cut through them; in the former case remaining flanked by stratified masses, which repose upon them in evident unconformity.[4]

[1] Comparative Tables in Geol. by H. T. de la Beche, pp. 38, 500. Humboldt on Superposition, pp. 30, 41, 114, 130, 133, 357. Lyell's

Prin. Geol. vol. iii. pp. 5, 10, 108, 324, 332, 374, 386—393. Jamieson's Cuvierian Theory, pp. 298—300. Sir H. Davy's Agricult. Chemistry. Geol. by Dr. M'Culloch, vol. ii. pp. 68—80. Prof. Buckland's Bridg. Treat. vol. i. p. 39. New Walks in an Old Field, Miller, 1841. Ancient World, by Ansted. Lyell's Elements of Geol. vol. i. pp. 4, 10, 21, 182—187, 191, 209. Phillips's Geol. pp. 42, 45, 68, 69, 95, 259. De Luc's Letters, No. 1, pp. 7, 8, 60—65.

[2] Manual of Geol. by H. T. de la Beche. Playfair's Huttonian Theory, pp. 84, 85. Jamieson's Cuvierian Theo. pp. 297, 298. Edin. Phil. Jour. No. xv. p. 121. No. xvi. p. 244. Lyell's Prin. of Geol. vol. iii. pp. 10, 108, 117, 334, 353, 364, 377. Geol. by M'Culloch, vol. i. p. 12. Brooke's Crystallography, p. ii. Prof. Buckland's Bridg. Treat. vol. i. pp. 5, 36, 40, 55. Lyell's Elements of Geol. vol. ii. pp. 246, 247. Phillips's Geol. p. 259.

[3] Geol. by H. T. de la Beche. Edin. Philos. Trans. No. xv. p. 121. Humboldt on Superposition, pp. 68, 69. Playfair's Hutt. Theory, pp. 52, 83, 209. Cuvier's Eloge. of Werner. Nat. Philos. by Sir John Herschel, pp. 284, 285. Lyell's Prin. of Geol. vol. i. p. 156. vol. iii. pp. 10, 37, 79, 353. Prof. Playfair's Works, vol. iii. pp. 410, 413. Lyell's Elements of Geol. vol. i. p. 21. New Walks in an Old Field, Miller, 1841.

[4] Geol. by H. T. de la Beche. Playfair's Hutt. Theory, pp. 47, 50, 83, 209, 230, 247, 311. Lyell's Prin. of Geol. vol. i. pp. 61, 101, 156. vol. iii. pp. 77, 117, 164, 185, 364. Gloss. p. 79. Lithological Survey of Schehallion, Playfair's Works, vol iii. pp. 403—440. New Walks in an Old Field, Miller, 1841. Capt. Ross's 2nd Voyage, 1829—1833. Capt. Parry's Voyage to Nothern Seas. Jamieson's Cuvierian Theory, p. 298. Geol. by Dr. M'Culloch, vol. i. p. 12. Prof. Buckland's Bridg. Treat. p. 36. vol. 2. pp. 3, 4. Phillips's Geol. pp. 42, 55—57. Lyell's Elem. of Geol. vol. ii. p. 264, et seq.

24. That there exists an essential mineralogical difference between the older crystalline rocks, such as granite, trap, porphyry, serpentine, and others of that age and denomination, considered to be of igneous origin, and those which have been ejected from modern volcanoes, distinguished by the name of lavas,[1] a difference attributed to the greater pressure under which the older masses were formed, to the non-action of the atmosphere and consequent retention of their gaseous or volatile parts, and to the more gradual manner in which they have cooled down.[2]

[1] Geol. by De la Beche, pp. 493, 501. Nat. Philos. Cab. Cyc. p. 269. Playfair's Hutt. Theory, pp. 67, 80, 260, and his own Works, vol. i. pp. 97—108. Lyell's Prin. of Geol. vol. i. pp. 147, 456. vol. ii. pp. 11, 108, 117, 124, 353, 359, 364. Whitehurst's Theory of the Earth, p. 245,

et seq. Lyell's Elements of Geol. vol. i. p. 14. vol. ii. pp. 189—195, 201—254, almost throughout. Phillips's Geol. pp. 187, 238, 240.

[2] Geol. by De la Beche, pp. 5, 475, 47. Nat. Philos. Cab. Cyc. pp. 269, 270. Playfair's Hutt. Theory, pp. 21, 68, 135, 181, 184, 260. Lyell's Prin. of Geol. vol. i. p. 148. vol. iii. pp. 108, 124, 353, 360, 363, 370. Whitehurst's Theory of the Earth, p. 245, et seq. Prof. Buckland's Bridg. Treat. vol. i. p. 41. Lyell's Elements of Geol. as above. Phillips's Geol. as above.

25. That GRANITE is found to be essentially the same wherever it hitherto has been examined. That it is in the deeper regions of the globe, where granite has its origin, that that of trap must also be looked for. That whatever difference may exist between these rocks, whether in their relation to the strata or their mineralogical character, they are remarkably analogous in almost every important general circumstance.

And that there is good reason even for considering that granite, porphyry, and trap have had a common origin.

Geol. by Dr. M'Culloch, vol. i. pp. 145—160, 196. vol. ii. pp. 81—83, 93, 102, 412. Lyell's Prin. of Geol. vol. iii. pp. 361—363. Playfair's Works, vol. i. p. 95, et seq. Prof. Buckland's Bridg. Treat. vol. i. pp. 46—48, and map in vol. ii. Phillips's Geol. pp. 32, 33, 42—45. Ancient World, by Ansted, pp. 16, 17. Lyell's Elements of Geol. vol. i. pp. 14, 20. vol. ii. pp. 186, 191—197, 200, et seq. De Luc's Letters, Intro. pp. 58, 142. Letter 2nd, p. 67. Geol. by H. T. de la Beche, p. 486, et seq. Old Red Sandstone, by Miller.

26. That the granitic, trappean, serpentinous, and porphyritic descriptions of amorphous rocks generally constitute the nucleii or centres of mountain ranges, and together with their recumbent strata attain the greatest elevations throughout the world.[1] And that conjointly they occupy a considerable portion of its terrestrial surface.[2]

[1] Playfair's Hutt. Theory, pp. 84, 343. Jamieson's Cuvierian Theory, p. 298. Geol. by H. T. de la Beche, pp. 484, 485. Sir H. Davy's Agricult. Chemistry. Lyell's Prin. Geol. vol. i. p. 115. vol. iii. pp. 10, 283, 353. New Walks in an Old Field, Miller, 1841. Capt. Ross's Voyage, 1829, p. 33. Playfair's Works, vol. ii. pp. 403—440. Geol. by Dr. M'Culloch, vol i. pp. 132, 133. vol. ii. p. 89. Literary Gazette, 5th Nov. 1836, pp. 714, 715. Prof. Buckland's Bridg. Treat. vol. ii. pp. 3—10. Lyell's Elements of Geol. vol. ii. pp. 147, 185, 345—424. Vindiciæ Geol. p. 18. Phillips's Geol. pp. 42, 60, 71—79. De Luc's Letters, No. 1, pp. 7—9, 60—63.

[2] Playfair's Hutt. Theory, pp. 342, 350. Geol. by H. T. de la Beche,

pp. 483—485. Capt. Ross's Voyage during 1829—1833. Lyell's Prin. of Geol. vol. iii. pp. 108, 381. Literary Gazette, 5th Nov. 1836, p. 714. Geol. by Prof. Phillips, pp. 32, 33, 42. De Luc's Letters. Lyell's Elements of Geol. vol. ii. p. 186, et seq.

27. That in mountain ranges certain axis of elevation are recognizable; while the outlines of the former frequently assume lengthened, irregular, conical forms, with one or more peaks, whose nucleii and apices usually consist of primary rocks.

And that it may be considered as an established fact, both in geology and geography, that these ranges are, in general, comparatively less elevated in extreme latitudes.

Geol. by H. T. de la Beche, pp. 484—486, 490, 513. Playfair's Hutt. Theory, p. 307. Jamieson's Cuvierian Theory, p. 298, and map. Lyell's Prin. Geol. vol. i. p. 61. vol. iii. p. 353. Playfair's Works, vol. iii. pp. 410—413. New Walks in an Old Field, Miller, 1841. Any geological map of mountain ranges. Any scale of the comparative heights of mountains. Edin. Phil. Jour. No. xvi. pp. 233, 234. Phillips's Geol. pp. 59—62. Captains Ross and Parry's Voyages to the Arctic Regions. The Connexion of the Sciences, pp. 56, 86. Lyell's Elements of Geol. vol. ii. pp. 30, 185, 277—304, 371—373. Phillips's Geol. pp. 8, 60, 71, 93, 266—270. Ancient World, by Ansted, 1847, pp. 106, 107, et seq. De Luc's Letters, No. 1, pp. 7, 60.

28. That it is not only the greater geographical height of the inter-tropical mountains which denotes the presence of a comparatively increased force in the regions where they are elevated, but their geological structure corroborates the same assumption. For, "rocks similar to those which constitute the ridge of Jura in the Alps, are found to occupy the plains of England; and basalts which repose on the granites of the Andes are discovered beneath the limestone of Skye."

Geol. by Dr. M'Culloch, vol. i. p. 8. De Luc's Letters throughout, espec. pp. 60—62. Letter 3rd pp. 106, 107.

29. That when a view is taken of any geological map, it is observed that the formations represented by it are intersected by veins of granite, porphyry, senite, trap, serpentine, greenstone, &c., and by dykes of similar material, especially of trap and basalt. That whatever may be the nature or position of the formations through which they pass, the *general* direction

of the main trunks of these veins and dykes is perpendicular to the earth's surface, although their branches frequently diverge and weld the several formations together in a remarkable manner. And that overlying masses of the same materials are frequently found on the surface as if they had overflown from the veins while in a state of fusion.

Playfair's Hutt. Theory, pp. 55, 63, 74, 81, 87, 313. Geol. by H. T. de la Beche, pp. 491—493. Trans. Camb. Soc. Edin. Review, No. lxxiii. pp. 239—248. Lyell's Prin. Geol. vol. i. pp. 71, 302. vol. iii. pp. 12, 36, 90, 357, 371, 372. Geol. by Dr. M'Culloch, vol. ii. pp. 90, 95, 143. Prof. Buckland's Bridg. Treat. map in vol. ii. pp. 3—5. Phillips's Geol. pp. 42, 62, 111, 112, 186. Lyell's Elements of Geol. vol. i. p. 12. vol. ii. pp. 185—187, 202, 212—219, 262, 357—372.

30. That two distinct classes of mineral veins are found to exist in the earth's outer crust—one of which proceeds from inwards outwards, having their basis in the interior, and their apici nearest to the surface; and the other, termed *Faults* and *Fissures*, proceeding from outwards inwards, with their apici in the interior and their basis on or near to the surface. And that displacement of the strata is almost invariably attendant on the faults above referred to.

Werner on Veins, pp. 50—59, 64, 90, 104, 110, et seq. Humboldt on Superposition, pp. 413, 414. Playfair's Hutt. Theory, pp. 61—66, 74, 87, 311. Lyell's Prin. Geol. vol. iii. pp. 36, 353—357, 371. Geol. by Dr. M'Culloch, vol. i. pp. 139—145, 163—165. Geol. by H. T. de la Beche, p. 165, et seq. Prof. Buckland's Bridg. Treat. vol. i. pp. 542—545. Geol. of England and Wales, by Rev. W. Conybear, part. i. p. 348. Lyell's Elements of Geol. vol. i. pp. 12, 127—134. vol. ii. pp. 213, 311. New Walks in an Old Field, Miller, 1841, sectional view in frontispiece. Vindiciæ Geol. pp. 18—21. Phillips's Geol. pp. 62—108, 110, 260—265. De Luc's Letters, No. 3, pp. 125—128.

31. That in the Coal Measures there is considerable persistency of character; those termed "independent" being usually found in strata conformably to and overlying the mountain limestone and the old red sandstone; the whole three formations appearing to have been moved simultaneously, by the influence of great force, from where they were originally formed. That the magnesian limestone and new red sandstone, which usually overlie the coal measures, are, on the other hand, unconformable to them and more horizontal in

their position. That the lower portion of the new red sandstone series is generally formed of conglomerate and strata. And, finally, that there is a decided difference between the coal found in the independent formations, and the lignite or brown coal of the more recent deposits.

Geol. by Dr. M'Culloch, vol. ii. pp. 295—334. Geol. by H. T. de la Beche, pp. 413—448. Art. Coal, Dr. Ure's Chem. Dic. Prof. Buckland's Bridg. Treat. vol. i. pp. 64, 524. Lyell's Elements of Geol. vol. i. pp. 29, 30. vol. ii. pp. 95, 104, 105, 121, 131, 145, 279—297. Ancient World, by Ansted, p. 73, et seq. New Walks in an Old Field, Miller, 1841. Vindiciæ Geol. pp. 18—21. Connexion of the Sciences, p. 86. Botany, by Prof. Henslow, Cab. Cyc. pp, 202, 311. De Luc's Letters, iv. pp. 110, 155—157, 162. Ancient World, by Ansted, 1847.

32. That the formation called the New Red Sandstone Group is considered to be of mechanical origin and of heterogeneous composition; containing different kinds of fossil salts associated with gypsum, and much conglomerate and breccia.

That, conjointly with the oolitic group, it frequently contributes to form extended tracts of level land, having aided in filling up immense hollows on the earth's surface at a time when, or immediately after, this latter had undergone a great and widely extended revolution in its physical form, and in the condition of its vegetable and animal life.

And that although most usually the deposits of rock salt are associated with the strata of the new red sandstone formation, yet they are not unfrequently found in the oolitic, cretacious, and even in the tertiary formations.

Lyell's Prin. Geol. vol. iii. pp. 228—230, 333, 392. Humboldt on Superposition, pp. 308—324, 345. Dr. Murray's Elements of Chemistry, vol. ii. p. 291. Chemistry, by Hugo Reid, p. 142. Geol. by H. T. de la Beche. Smith's Geol. of England, in No. lvii. Edin. Review, p. 330. Hist. of British Animals, by Dr. Fleming, p. xvi. Cuvier's Eloge. of Werner. Geol. by Dr. M'Culloch, vol. i. pp. 274, 482. vol. ii. pp. 37, 214, 227, 232, 260, 288—294. New Walks in an Old Field, Miller, Edin. 1841. Prof. Buckland's Bridg. Treat. vol. i. pp. 3, 71, 390. Ansted's Ancient World, pp. 106—118, 130, et seq. Lyell's Elements of Geol. vol. i. pp. 104, 140, 201, 367—370. vol. ii. pp. 90—96, 102, 134, 242, 282, 350, 357. Phillips's Geol. pp. 65, 114, 120—140. De Luc's Letters, iii. pp. 131—136.

33. That whatever may have been the nature and extent

of the revolution, alluded to in the preceding theorem as having affected the earth's surface, it and its attendant circumstances seem to have exercised a direct and material influence over the widely extended deposits, the "OOLITIC" and the "CRETACIOUS GROUPS;" the CHALK formation being considered the most recent of the secondary series; after whose deposition there appears to have taken place a manifest change in the state and condition of our planet, and also in its vegetable and animal existences.

Geol. by H. T. de la Beche, p. 259, et seq. Humboldt on Super. pp. 68, 377. Bakewell's Intro. to Geol. Playfair's Hutt. Theory, pp. 25, 26. Edin. Phil. Jour. No. xvi. p. 228. Lyell's Prin Geol. vol. i. pp. 154—158, 161, 550. vol. ii. p. 313. vol. iii. pp. 16, 18, 172, 243, 320, 342. Geol. by Dr. M'Culloch, vol. i. pp. 138, 292, 482. vol. ii. pp. 262, 263. Prof. Buckland's Bridg. Treat. vol. i. pp. 71—77, 267, 273, 282, 334—375, 450. Phillips's Geol. pp. 33, 34, 92, 140, 154, 161, 186—194. Ansted's Ancient World, pp. 106—110, 254, 267, 400. Lyell's Elements of Geol. vol. i. pp. 194, 270, 337, 346, 386, 421. vol. ii. pp. 74, 79, 308—313, 349, 401—403. Old Red Sandstone, by Miller, Edin. 1841.

34. That in several parts of Europe and America immense quantities of travelled debris, gravel, and massive Bowlders, termed by Sir H. de la Beche "THE ERRATIC BLACK GROUP" are found either resting on or embedded in the soil. That the bowlders and larger debris, when they have been traced to the nearest fixed group of the same mineralogical character, are generally found to have come from a considerable distance. That those bowlders in Britain, Germany, Russia, and North America, whose sites and derivations are ascertained, have been identified with mountain chains existing to the *north* of where they now lie; whilst those in South America seem, on the contrary, to have originated from localities *southward* of their present resting places. Finally, the position of the gravel and smaller detrites appears to have been materially modified by local formations.

Playfair's Huttonian Theory, pp. 384, 385, 393, 394. Geol. by H. T. de la Beche, p. 169, et seq. Whitehurst's Theory of the Earth, 1786, pp. 63—66, et seq. Jamieson's Cuvierian Theory, pp. 300, 301. Lyell's Prin. Geol. vol. i. p. 202. vol. iii. p. 148. Geol. by Dr. M'Culloch, vol. ii. p. 364, 365. Literary Gazette, Feb. 3, 1836, p. 104, and Sept. 3, 1836, p. 565, both by Prof. Murchison. New Walks in an Old Field,

Miller, 1841. Phillips's Treat. on Geol. pp. 201, 205—216. Ansted's Ancient World, pp. 323—326. Lyell's Elements of Geol. vol. i. pp. 142, 164, 222—225, 231—234, et seq. vol. ii. p. 282, et seq. De Luc's Letters, Intro. p. 25. 1st Letter, pp. 17, 27, 38.

35. That a satisfactory explanation of the trade winds has been given upon certain well-known and established principles, amongst which the following are relevant to the present subject:—

1st. That all portions of the earth's surface have a velocity of rotation in direct proportion to the radii of the circle of latitude to which they correspond.

2nd. That the air, when relatively and apparently at rest, is only so because it participates in the motion of rotation proper to that part of the earth.

3rd. That, consequently, when currents of air set towards the equator from the north or south, they must lag, hang back, or drag upon the surface, in a direction *opposite* to that of the earth's rotation, or from east to west. And, lastly,

That the polar currents, from a deficiency of rotatory velocity, tend by their friction near the equator to diminish the velocity of the earth's rotation; while, on the contrary, the equatorial currents carry the excess of rotatory motion north and south.

Astron. by Sir John Herschel, pp. 128—132. Prof. Whewell's Bridg. Treat. p. 99. Whitehurst's Theory of the Earth, 1786, p. 148, et seq. System. of Astron. by Margaret Bryan, 1797, p. 309, et seq. Connexion of the Sciences, pp. 8, 87, 115, 137, 433, 441. Capt. Hall's Voyages and Travels, 2nd series, vol. i. p. 162. Lyell's Elements of Geol. vol. i. pp. 34, 140, 224. vol. ii. p. 301. Prin. of Meteorology, by Hutchinson. Meteorology, by Dr. Thomson, 1849, pp. 380—382.

36. That the great size of fossil plants, and the magnitude of fossil shells, when compared with their respective recent equivalents, afford reason to suppose that there existed, when and where they grew and lived, as great a *warmth of temperature** as now exists within the tropics, and, perhaps, even greater. That this warmth was general throughout the

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* This "warmth of temperature" must be carefully distinguished from the *heat* which is alluded to in the 20th and 29th theorems, and which is considered to have occasioned the fusion observable in the primary and secondary formations.—Author.

northern, and such parts of the *southern* hemisphere as have yet been examined.

And it is also considered that there existed in the medium wherein they grew and lived a much greater proportion of carbonic acid than is consistent with present animal and vegetable life.

Botany, by Prof. Henslow, Cab. Cyc. pp. 313, 314. Botany, in Libr. of Usef. Know. p. 89. Connexion of the Sciences, pp. 85, 256—272. Manual of Geol. by H. T. de la Beche. Lyell's Prin. Geol. vol. i. pp. 105—118, 145. vol. iii. p. 55. Gloss. p. 72. Elem. Philos. Plants, Decandolle and Sprengel, p. 276. Humboldt on Superposition, pp. 46, 52. Edin. Jour. Nat. Hist. p. 63. Prof. Buckland's Bridg. Treat. vol. i. pp. 452, 462, et seq. Capt. Parry's Voyage, Edin. Phil. Jour. No. vii. p. 152. Fossil Flora, by Lindley and Hutton, vol. i. Ancient World, Ansted, p. 80, et seq. Lyell's Elements of Geol. vol. i. p. 285, 382. vol. ii. p. 125. Phillips's Geol. pp. 96, 118, 289. De Luc's Letters, p. 110, also Letter v. Architecture of the Heavens, Nichols, p. 106. Old Red Sandstone, H. Miller, 1841.

37. That, besides the phenomena alluded to in the foregoing theorems, reference is made, generally, in Geological Treatises:—

1st. To the changes which are taking place, as the effects of causes now in operation, such as the action of the sea, its encroachments and subsidencies, tides, currents, lakes, and rivers, volcanoes, earthquakes, deposits from springs, and the formation of coral reefs and islands. And

2nd. To the fossil osteological remains of extinct animals, found in various formations, which the industry of geologists has brought to light, arranged, described, and designated by names, usually derived from Greek compounds, expressive of their anatomical developments, and which seem to prove, almost invariably, that the former possessors of these fossilized bones, were wholly distinct from, and not varieties of living species.

Prof. Buckland's Bridg Treat. vol. i. pp. 79, 94, et seq. Ancient World, by Ansted, London, 1847. Old Red Sandstone, Miller, Edin. 1841. Lyell's Prin. and Elements of Geol. Vindiciæ Geol. pp. 6—9, from Cuvier, pp. 30—38. Phillips's Geol. pp. 184, 211—221, 226. De Luc's Letters, and any modern work on Geology.

38. That LIGHT, according to the Newtonian hypothesis,

is supposed to consist of inconceivably minute, material particles, emitted by luminiferous bodies, and moving through space with the velocity of 192,000 miles in a second of time. That, according to the *Undulatory* Theory, an exceedingly thin and elastic medium called ETHER is supposed to fill all space, and to occupy the intervals between the particles of materials bodies; and that the vibrations or undulations of this etherial medium cause the sensation of LIGHT.

But, whatever may be the mode by which it is considered that light becomes perceptible, its universality and the almost immeasurable distance at which it is perceived throughout space, as well as the amazing rapidity of its vibrations requisite to convey sensations of colour are alike remarkable.

Optics, by Sir D. Brewster, Cab. Cyc. pp. 2, 134, 283. Nat. Philos. by Sir John Herschel, pp. 94, 195—217, 248, et seq. Progress of Philos. Science, by J. Thomson, pp. xxxiv. xxxix. System of Astron. by Margaret Bryan, pp. 5—15. Connex. of the Sciences, pp. 38, 186—188, 190—193, 220—224. Prof. Buckland's Bridg. Treat. vol. i. p. 32. Prof. Whewell's idem, pp. 129, 130. Chemistry, Cab. Cyc. pp. 40—42, 373—375. Heat, idem, p. 400. Electricity, idem, pp. 226, 227. Daniel's Philos. of Chemistry, pp. 164—175, 191. De Luc's Letters, pp. 74—80. Architecture of the Heavens, Nichols, 1837. Meteorology, by Dr. Thomson, 1849, p. 80, et seq.

39. That a pencil of LIGHT can be decomposed either by refraction or by absorption into three primary spectra: namely, a red, a yellow, and a blue spectrum; or into seven distinct colours when the secondary ones are included, viz: red, orange, yellow, green, blue, indigo, and violet. That it likewise can, by the application of certain refracting and absorbing media, be polarized, or separated into two distinct pencils; one having its pole+45° and another whose pole is —45°. And, that the angle at which LIGHT falls on any object and the intervening media very materially affect the the nature of the result.

Optics, by Sir D. Brewster, Cab. Cyc. pp. 66—72, 144—147, 159—169, et seq. Connexion of the Sciences, pp. 177, 180, 200, 225, 452. Heat, in Cab. Cyc. pp. 295—297, 399. Daniel's Philos. of Chemistry, pp. 179—181, 193—207. Botany, in Cab. Cyc. pp. 195—198. Hunt on Light, pp. 37—39. Meteorology, by Dr. Thomson, 1849, pp. 37, 218, et seq.

40. That there are two hypothesis respecting the con-

stitution of *Solar Light*, by one of which it is considered to be comprised of different physical principles; and by the other it is supposed to consist of a number of distinct rays capable of being diversely deflected, and possessing different qualities according as they vary in refrangibility. Yet, by the adherents of both hypothesis it is admitted, *that the solar rays do possess chemical properties.*

Heat, in Cab. Cyc. pp. 298—303, 399. Optics, idem, by Sir D. Brewster, pp. 90—93. Art. Light, in Dr. Ure's Chem. Dict. pp. 578—580. Connexion of the Sciences, pp. 225—227. Daniel's Philos. of Chem. p. 456. Hunt on Light. Taylor's Scient. Mem. vol. iii. p. xi. Feb. 1843. De Luc's Letters, p. 78. Meteorology, by Dr. Thomson, 1849, p. 37, et seq. (founded on numerous concurring authorities).

41. That the surface, lengthways, of the solar spectrum is crossed by dark lines of different breadths, and amounting in number to nearly six hundred. That when sun or moon-light is employed in the experiment, their number, order, and intensity are found to be invariable. And that similar bands are perceived in light from the fixed stars, and from that afforded by electricity; but in the light given by a lamp or candle none of these fixed lines are perceptible.

Optics, by Sir D. Brewster, Cab. Cyc. pp. 85—88, 142. Connexion of the Sciences, pp. 180—182. Astron. by Sir John Herschel, pp. 202, 203. Daniel's Philos. of Chem. pp. 183, 457. Hunt on Light, pp. 40, 41. Meteorology, by Dr. Thomson, 1849, p. 80.

42. That some late and delicate experiments in optics having proved that rays from the sun, even when transmitted obliquely, are *not* polarized, whereas those which emanate from encandescent bodies possess this remarkable property, it follows as a consequence, that solar light does not issue from an encandescent solid or fluid, but rather—as Herschel previously supposed—from an exterior film which is the source of its light; and that the intensity of the sun's light diminishes from the centre to the circumference of the solar disc.

Astron. by Sir John Herschel, Cab. Cyc. p. 212. Connexion of the Sciences, pp. 254, 255, 310. Geol. by Dr. Ure, Intro. p. xxxvi. Prof. Whewell's Bridg. Treat. p. 171. Heat, in Cab. Cyc. p. 314. Architec. of the Heavens, Nichol, 1837. Phen. and Order of the Solar System, idem, pp. 170—199. Meteorology, by Dr. Thomson, 1849, p. 83, et seq.

43. That common light moves in straight lines. That when it falls upon any surface, whether plane or curved, the angle of its reflection is equal to the angle of its incidence. That the intensity of radiant heat and light decreases in direct proportion to the square of the distance. And that one non-luminous body may receive light from another non-luminous body and discharge it upon a third; but in every case *the light must come from a self-luminous body.*

Optics, by Sir D. Brewster, Cab. Cyc. pp. 1, 6, 23—25. Connexion of the Sciences, pp. 170—176, 189. Chemistry, in Cab. Cyc. p. 91. Astron. by Sir John Herschel, p. 212. Daniel's Philos. of Chem. p. 166.

44. That the following are some of the best ascertained effects of sunlight upon the vegetable kingdom, namely:—

1st. The quantity of water lost to a plant by evaporation, and its power of absorption from the soil are in proportion to the quantity of light.

2nd. Light causes the decomposition of the carbonic acid of vegetation; and, by solidifying the tissue, renders the parts most exposed to it the hardest. And

3rd. The green parts of plants, when exposed to the direct light of the sun, absorb from the atmosphere carbonic acid, which they decompose, and give back the oxygen.

Botany, by Prof. Henslow, Cab. Cyc. pp. 92, 175, 186. Botany, in Lib. Useful Know. pp. 84—88. Hunt on Light, pp. 200—202. Meteorology, by Dr. Thomson, p. 15 (founded on numerous concurring evidences).

45. That two distinct hypothesis have been proposed respecting the nature of RADIANT HEAT.

By one it is considered to be a material substance *sui generis*, capable of combining with other bodies, and by such combination producing the various effects attributed to heat. By the other it is regarded, not as a material substance, but as a *quality* of matter; bodies when heated being supposed to be in a certain state in which their constituent molecules, or the molecules of some subtle fluid which pervades them, are put into a state of vibration; and this vibration is considered the cause of heat.

Heat, in Cab. Cyc. pp. 26, 379, 392—403. Chemistry, by Donovan,

Cab. Cyc. pp. 40—42, 375—378. Daniel's Philos. of Chem. pp. 164, 208, 228, 685. Connexion of the Sciences, p. 411. Disc. on Nat. Philos. by Herschel, pp. 195, 310—323. Pollock's Attempt to Explain the Nature of Heat.

46. That the results of careful and repeated experiments prove, "that light and heat either do not possess the property of gravitation, or possess it in so small a degree as to be wholly inappreciable by any known means of measuring it."

Heat, in Cab. Cyc. pp. 394—396. Connexion of the Sciences, pp. 239, 240. Chemistry, by Hugo Reid, p. 102. Chemistry, in Cab. Cyc. pp. 373—375. Electricity, in idem, pp. 1, 227. Daniel's Philos. of Chem. p. 102. Nat. Philos. by Sir John Herschel, p. 300. Hydrostatics, in Cab. Cyc. p. 142.

47. That a comparison of the natural phenomena, in which the effects of Light and Heat are manifested, affords reason to infer the existence of a connexion so intimate between them as to warrant the belief of their identity. Nevertheless, although the instances are rare in which light does not emanate from incandescent bodies; yet, on the other hand, intense heat may be excited and communicated without being accompanied by visible light.

Heat, in Cab. Cyc. pp. 22—25, 294, 339—353, 379—381, 398. A Paper read before the Royal Society by Herschel, May 15, 1800, p. 295. Dr. Faraday's Exper. Researches, vol. ii. System of Astronomy, by Margaret Bryan, 1797, pp. 5—15. Connexion of the Sciences, preface, also pp. 226—233, 237—249, 251, 355. Disc. on Nat. Philos. by Herschel, Cab. Cyc. p. 314. Prof. Whewell's Bridg. Treat. p. 136. Lectures at the Lond. Instit. by Prof. Grove, 1843 and 1844. Chemistry, in Cab. Cyc. pp. 40—42, 91. Hydrostatics, in idem. Electricity, in idem, pp. 162, 163. Daniel's Philos. of Chem. pp. 164—166, 208, 217. De Luc's Letters, pp. 76—80.

48. That by a concurring chain of deductive reasoning, drawn from the effects of the different heating powers of the component colours of the solar spectrum, when applied to substances reflecting various colours and degrees of heat; together with the corroborating testimony of the augmented heat of concentrated light, it is considered to be established, beyond the possibility of doubt, that, in these cases, sunlight is the direct cause of heat.

Heat, in Cab. Cyc. pp. 345—350, 382. Connexion of the Sciences,

p. 229. Optics, by Sir D. Brewster, Cab. Cyc. pp. 89, 317, 321. Chemistry, in Cab. Cyc. p. 91. Daniel's Philos. of Chemistry, pp. 99, 209.

49. That the *attraction of affinity*—distinct from that of cohesion, and the highest degree of heterogeneous attraction, its ratios being determinate quantities—is supposed to be co-existent with matter.

That it is one of the few forces known to act by election, and is productive of the most important results in nature.

And, that during chemical action, heat is either developed or absorbed; whilst caloric and water are the agents most usually employed to facilitate and conduct chemical operations.

Heat, in Cab. Cyc. pp. 3, 21, 25, 191—193, 294—296, 310, 354, 387. Disc. on Nat. Philos. in Cab. Cyc. pp. 310—313. Caloric and Combustion, Ure's Chem. Dict. pp. 353, 368. Chemistry, by Hugo Reid, p. 22, et seq. Connexion of the Sciences, p. 225. Chemistry, in Cab. Cyc. pp. 23—27, 384—386, et seq. Electricity, in idem, p. 162. Daniel's Philos. of Chemistry, pp. 101, 219, 306, 325, 338, 397, 444, 523, 685. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. pp. 2, 3, et seq. Dr. Faraday's Chem. Manipulations.

50. That the first and most usual effect of heat is to increase the size of the bodies to which it is imparted, by causing them to dilate or expand.

That, although these effects are produced in different degrees and by different methods, according as the body to which heat is applied be solid, liquid, or aeriform, yet it may be considered as a physical law to which there is no *real* exception, that an increase in the temperature will be accompanied by an increase of volume, and a diminution of temperature by a diminution of volume. And that the force with which solids and liquids expand or contract by heat or cold is prodigious.

Heat, in Cab. Cyc. pp. 8—10, 28—83, 162, 173—175, 187—189, 393. Connexion of the Sciences, pp. 117—120, 243. Chemistry, by Hugo Reid, pp. 22, 23. Mechanics, in Cab. Cyc. pp. 19, 20. Heat, in Chem. Dict. pp. 253—255, 278. Disc. on Nat. Philos. in Cab. Cyc. pp. 319—322, 343. Chemistry, in Cab. Cyc. pp. 10, 42—48, 54—58. Daniel's Chem. Philos. pp. 685—687. Meteorology, by Dr. Thomson, 1849, p. 98, et seq.

51. That the phenomena arising from *attraction* and those from *repulsion* indicate the presence of two antagonist forces acting at the same time on the particles of all bodies, and maintaining them in a state of equilibrium; which becomes more or less disturbed according as either of these forces preponderates.

Heat, in Cab. Cyc. pp. 2, 8, 11, 17, 185—199, 343. Chemistry, by Hugo Reid, pp. 20—23. Disc. on Nat. Philos. by Sir John Herschel, Cab. Cyc. pp. 89, 321. Connexion of the Sciences, pp. 117, 241—243. Chemistry, in Cab. Cyc. pp. 37—44, 49, 58. Hydrostatics, in idem, p. 2. Electricity, in idem, pp. 225, 226. Daniel's Philos. of Chemistry, pp. 13, 17, 99, 450. Mechanics, in Cab. Cyc. pp. 8, 67. Meteorology, by Dr. Thomson, 1849, p. 370.

52. That an irresistible body of analogies leads to the conviction, that the same physical properties, which observation and experience disclose in the smaller masses immediately surrounding us, are possessed by the infinite systems of bodies which fill the immensity of space. That the distribution of heat is regulated by the same laws amongst the bodies of the universe as among those which exist on our globe. That the earth absorbs and radiates heat in the same manner as every body on its surface, and therefore, if there were no external source of heat, the earth would be gradually cooled down and the temperature of all bodies would fall indefinitely.

Heat, in Cab. Cyc. pp. 186, 379—382. Prof. Whewell's Bridg. Treat. p. 76. Dr. Faraday's Researches, vol. ii. pp. 284—293. Daniel's Philos. of Chem. p. 215. Constitut. Sidereal System, Lond. Edin. and Dub. Mag. Feb. 1843. Connexion of the Sciences, pp. 29, 363, 381—389, 401—411. Mechanics, in Cab. Cyc. p. 80. Architect. of the Heavens, Nichol, 1837. Phen. and Order of the Solar System, pp. 218—234.

53. That when a liquid passes into a solid state a sudden and considerable change of dimension is frequently observed; and that it may be considered as a general truth, to which, however, there are exceptions, that bodies which crystallize when they freeze, expand in doing so; while bodies which do not crystallize in solidifying, for the most part suffer contraction.

Heat, in Cab. Cyc. pp. 128—131. Chemistry, in idem, pp. 52—58.

54. That water in vacuo boils at 88° of Fahrenheit; but, under the usual pressure of the atmosphere it requires 212°. While, in order to maintain water in a state of vapour, the sum of its latent and sensible heats cannot be less than from 1,130° to 1,212°.

That different bodies undergo the process of liquifaction at different temperatures, called their points of fusion. In like manner, different liquids undergo the process of ebullition, under equal pressure, at different temperatures.

And, lastly, that the states of solidity, liquidity, or of vapour, are not essentially connected with the nature of bodies, but are wholly incidental on their temperature.

Heat, in Cab. Cyc. pp. 15, 118, 127, 143, 151, 166, 183, 194. Dr. Ure's Chem. Dict. p. 283. Chemistry, by H. Read, pp. 36, 37, 101. Connexion of the Sciences, pp. 243—250. Chem. in Cab. Cyc. pp. 52—67, 73—75. Daniel's Philos. of Chem. p. 191. Espy on the Philos. of Storms, 1841. Meteorology, by Dr. Thomson, 1849, pp. 17—19

55. That oxygen, nitrogen, and hydrogen gases have been severally submitted, by the first chemists of the age, to the enormous pressure of eight hundred atmospheres, without their having succeeded in reducing either of them to the liquid state; although many other gases have been liquidized by their vigorous and well-directed exertions; and that hitherto no satisfactory explanation has been given of the condition in which the atmospheric elements exist in union.

Heat, in Cab. Cyc. pp. 167, 177—179, 192, 344. Connexion of the Sciences, p. 119. Phillips's Geol. p. 26. Chemistry, in Cab. Cyc. pp. 52, 97, 133, 138, et seq. Daniel's Philos. of Chemistry, pp. 57, 100, 310, 322. Meteorology, by Dr. Thomson, 1849, p. 7, et seq.

56. That the atomic theory is understood, by some, to imply that all substances are composed of atoms, on whose magnitude, density, and form their nature and qualities depend. Others, however, assume these atoms to be—not particles of matter—but *centres of force*, highly elastic, varying in the disposition and relative intensity of the forces around their respective centres; and to be in contact with each other. But all alike concur in the belief that, as these atoms are un-

changeable, they must be incapable of wear, remaining the same now as when created.

Dr. Dalton's Chemical Philos. vol. i. Nat. Philos. in Cab. Cyc. by Herschel, pp. 37—42, 323. Heat, in Cab. Cyc. pp. 185, 291—293. Connexion of the Sciences, pp. 117—128. Dr. Faraday's Experimental Researches, vol. ii. pp. 284—293. Chemistry, in Cab. Cyc. pp. 13—40, 361, 384—391. Daniel's Philos. of Chemistry, pp. 7, 313, 325, 678—695. Mechanics, in Cab. Cyc. pp. 6—16, 67. Phillips's Geology, p. 257. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. pp. 2, 3, et seq.

57. That when any physical effect is transmitted in straight lines, especially if these lines proceed in various directions round the point whence the effect originates, the phenomena is called *radiation.* The effect is said to be radiated, and the lines along which it is transmitted are called rays.

That radiation, in this sense of the term, is a property of heat, and is independent of any power of transmission which may reside in the air; while it is proved, that the particles forming the surface of a body are not the only ones which radiate, but that this effect also proceeds from particles at a certain small depth within the surface.

Connexion of the Sciences, p. 226. Heat, in Cab. Cyc. pp. 21, 294, 314. Chemistry, in Cab. Cyc. pp. 84—86. Daniel's Philosophy of Chemistry, pp. 209, 214, et seq.

58. That if heat be applied to a solution of salt and water, the repulsive force will cause the atoms of water to separate from the atoms of salt and carry the former away in pure vapour, while the salt will remain in the form of crystals; the same degree of repulsive force not being capable of overcoming the natural cohesion between *its* particles.

That precisely similar results will ensue if a solution of the same material be exposed to vaporization; which, if continued for a sufficient length of time, will cause the water to disappear altogether, and leave a crystalline mass of salt behind.

Heat, in Cab. Cyc. pp. 192, 207, 244. Dr. Ure's Chemical Dict. Chemistry, by Hugo Reid, pp. 115, 116. Chemistry, in Cab. Cyc. p. 19. Electricity, in idem, vol. ii. p. 81. Daniel's Philos. of Chemistry, pp. 77, 222—225. Mechanics, in Cab. Cyc. p. 14.

59. That ELECTRICITY is a physical agent, possessing the properties of a self-expansive fluid.

That all bodies, when in a state of solution, are conductors of electricity. That the mutual attraction or repulsion of two electrified bodies is directly proportional to the quantity of the fluid on the one multiplied by that which is on the other, and inversely proportional to the square of the distance between the two. And that, although several varieties of electricity are known to exist, dependant on the manner in which the electric force is excited, yet they are sufficiently related to one another to justify the conclusion that they all originate from a common principle, and are the effects of one individual power.

Electricity, in Cab. Cyc. vol. ii. pp. 355, 479—482. Connexion of the Sciences, pp. 121, 123, 288, 307, 335. Mechanics, in Cab. Cyc. p. 75. Discourse on Nat. Philos. by Sir John Herschel, pp. 327, 330—333. Lectures in Lond. Inst. by Prof. Grove, 1843, 1844. Harris on Thunderstorms, 1843. New Treat. on Mechanics, London, 1841, pp. 8—10. Meteorology, by Dr. Thomson, 1849, pp. 270—281, et seq.

60. That ELECTRICITY is confined, almost exclusively, to the surface of bodies, penetrating only to a depth scarcely appreciable. That the quantity which bodies are capable of receiving is neither proportional to their mass, nor is it affected by their component materials, but depends chiefly on the extent of their surface and their form. That the electric fluid is most easily retained by a sphere; next by a spheroid; while it readily escapes from a point; and a pointed object receives it with the greatest facility.

Electricity, Cab. Cyc. Nat. Philos. by Sir John Herschel, pp. 331, 332. Connexion of the Sciences, pp. 289—294. Harris on Thunderstorms, 1843. Exper. Researches, by Dr. Faraday, vol. ii.

61. That Light, Heat, and Motion are intimately connected with electrical phenomena. That the most splendid artificial light known is produced by attaching pencils of charcoal, diamond, &c., to the extremities of the wires of a voltaic current, and bringing the points thus prepared into contact. That the most intense heat is generated by electrical action, especially by voltaic electricity. And that some eminent phi-

losophers are inclined to attribute the light and heat of the sun to electrical agency.

Electricity, in Cab. Cyc. Harris on Thunderstorms, 1843. Disc. on Nat. Philos. by Herschel, p. 331. Connexion of the Sciences, pp. 294—313, 353—355. Stait's Electrical Light, Mining Journal, Jan. 1849. Meteorology, by Thomson, 1849, pp. 271, 368, et seq.

62. That there is a strong analogy between MAGNETISM and ELECTRICITY. The agency of attraction and repulsion is common to both, and subject in them to the same laws; their intensities varying inversely, as the square of the distance between the bodies is affected by them. That a like analogy extends to magnetic and electrical induction.

And that there is such a perfect correspondence between the theories of magnetic attraction and repulsion, and electro-dynamic forces in conducting bodies, that they not only are the same in principle, but are determined by the same formulæ. While experiment concurs with theory in proving that, with the exception of electrical transference, the identity of these two unseen influences is complete.

Electricity, in Cab. Cyc. Disc. on Nat. Philos. by Herschel, pp. 324, 339. Connexion of the Sciences, pp. 324—327, 331, 338, 341. Prof. Whewell's Bridg. Treat. pp. 110—115.

63. That ELECTRO-MAGNETISM (electricity modified by the physical influences peculiar to certain substances), by overcoming retardation arising from friction, and the obstacle of a resisting medium, maintains perpetual motion. That the force emanating thus mutually from the electric current and the magnetic needle, acts at right angles to the electric current.

"Such circumferential action, arising from the tangential direction of two opposite forces," being unlike any other power hitherto discovered; for, all other known forces emanating from a point and acting upon any other, act in the direction of a line joining these two points; and that in all experiments, undertaken with the design of eliciting the phenomena of electro-magnetism and of magneto-electricity (the converse of each other) rotation round an axis is generally found to accompany them.

Electricity, in Cab. Cyc. Disc. on Nat. Philos. by Herschel, pp. 93,

339. Connexion of the Sciences, pp. 305—309, 328, 338, 456. Edin. Philos. Jour. No. xi. p. 179. No. xv. p. 282. No. xvi. pp. 368—372.

64. That the magnetic action has a circular motion round the connecting wire of a voltaic current, whose course, always constant with respect to each of the poles of a magnet, is similar to the direction of the earth and other planets around the Sun, and about their respective axis; that currents of electricity, analogous to these are constantly flowing round the earth, at right angles to the magnetic meridian.

And by some it is considered, that the arrangement of the materials composing the outer crust of the globe may be such as to constitute a voltaic girdle, sufficient, though of feeble electric powers, to produce terrestrial magnetism.

Daniel's Philos. of Chemistry, p. 573. Electricity, in Cab. Cyc. Disc. on Nat. Philos. by Herschel, p. 328. Electro-Magnetism, by Dr. Roget, in Lib. Useful Know. Magnetism, in Pop. Encyc. pp. 833—837. Connexion of the Sciences, pp. 305, 324, 328, 348. Prof. Whewell's Bridg. Treat. p. 114. Electricity, in Cab. Cyc. p. 208. Edin. Philos. Jour. No. vii. p. 174.

65. That Electrical Induction is that remarkable influence which is exerted by electrified bodies on other bodies at such distances as to prevent the transfer of any part of the charge, but by which a polar state is communicated to the body under induction, so as to confer upon it equal but opposite powers by a common condition.

That the *magnetic* force of a conducting wire is capable of acting by *induction* on soft iron, and of cummunicating permanent polarity to steel; this latter induction taking place indifferently through all kinds of matter.

And that the laws of Terrestrial Magnetism, although inconsistent with those which belong to a permanent magnet, are perfectly accordant with the conditions peculiar to a body in a state of transient magnetic induction.

Electricity, in Cab. Cyc. Connexion of the Sciences, pp. 291, 347—353.

66. That in light, heat, electricity, and magnetism, principles are exhibited which, although they do not occasion any appreciable change in the weight of bodies, manifest their

presence by the most remarkable mechanical and chemical effects.

And that these agencies are so connected as to afford every reason to believe they will ultimately be referred to some one power of higher order, in conformity with the general economy of the system of the world; in which the most varied and complicated effects are produced by a small number of comprehensive laws.

Experimental Researches in Electricity, by Dr. Faraday, vol. ii. p. 15. Connexion of the Sciences, pp. 309, 352—355, 412, 413. Prof. Whewell's Bridg. Treat. p. 138. Harris on Thunderstorms, 1843. Meteorology, by Dr. Thomson, 1849, pp. 271, 278, et seq.

67. That one of the most important qualities of matter in mechanical investigation is INERTIA, or that property which results from its inability to produce in itself spontaneous change or action, either from a state of rest to that of motion, or vice versâ, to diminish any motion which it may have received from an external cause, or to change its direction.

That, since by this quality of *inertia*, a body can neither generate nor destroy motion, it follows: that when two bodies act on each other, in any way whatever, the total quantity of motion in any given direction after the action takes place, must be the same as before. And that any two bodies are considered to have equal quantities or masses of matter when they possess equal inertia.

Mechanics, in Cab. Cyc. pp. 27—33, 37, 38, 44, 63—74. Chemistry, in idem, p. 2. Electricity, in idem. p. 225. Daniel's Philos. of Chem. pp. 9, 10. Disc. on Nat. Philos. by Sir John Herschel, pp. 222, 297. Mechanics, by Laplace, Toplis, 1814, pp. 23—30. New Treat. on Mechanics, London, 1841, pp. 2, 83.

68. That the molecules of bodies are not placed together merely in unrelated juxtaposition, but either cohere and resist separation, or mutually repel each other; while the mutual approach, by attraction of particles placed at a distance from each other, or their further separation by repulsion, are effects of the same class, both of which are termed FORCE. That, therefore, "whatever produces or opposes the production of motion or pressure in matter is *force*;" in which sense it is

the name or symbol for the unknown *cause* of a known *effect*. That Force, when manifested by the mutual approach or cohesion of bodies, is called Attraction; separable into as many branches as it has distinct modes of displaying itself. But when Force is indicated by the remotion of bodies from each other it is called *repulsion* or *expansion*.

Mechanics, in Cab. Cyc. pp. 6—8, 49, 63. Discoveries by an Italian Philos. Lit. Gazette. Lectures, by Prof. Grove, Lond. Instit. 1843-4. Chemical Dict. Dr. Ure's, pp. 253, 278. Chemistry, in Cab. Cyc. pp. 27—30. Daniel's Philos. of Chemistry, pp. 11, 13—18. Disc. on Nat. Philos. Herschel, pp. 225—228. Mechanics, by Laplace, Toplis, 1814, p. 1, 30. New Treat. on Mechanics, London, 1841.

69. That the tendency to assume and maintain a state of equilibrium—the effect of counteracting forces—is a prevailing condition of the material universe; that it is exemplified alike by the invariable plane passing through the centre of gravity of the solar system, around which, as a fixed centre, the great secular changes of the system oscillate; by the static forms assumed by fluid bodies under rotation; by the normal condition of the ocean and of the atmosphere; and by the combinations produced by the satisfaction of chemical affinities; that the stability of the equilibrium or difficulty of subverting it, is in proportion to the magnitude and importance of the constituted body; and that it cannot be disturbed, in any of its states, without the operation of a sufficient and corresponding cause.

Mechanics, in Cab. Cyc. pp. 65, 74, 116. Connexion of the Sciences, pp. 306, 307. Disc. on Nat. Philos. by Sir John Herschel, Cab. Cyc. pp. 90, 222, 275, 281. Architecture of the Heavens, Nichol, pp. 185—187. Phen. and Order of the Solar System, idem, pp. 231, 232. Harris on Thunderstorms, pp. 4, 10. Ancient World, by Ansted, 1841, pp. 384, et seq. Meteorology, by Dr. Thomson, 1849, p. 370. Baron Humboldt's Cosmos.

70. That the law of Gravitation, is "That the mutual attraction of two bodies increases as their masses are increased, and as the square of the distance between them is diminished; and it decreases in proportion as their masses are decreased, and as the square of their distance is increased." That this

law—which is irrespective of the quality of matter—extends not only over the planetary system, where its effects have been submitted to rigorous calculation, but is supposed to pervade the whole material universe; and that, as the motions of celestial bodies are independent of their absolute magnitudes and distances, if all the bodies of the solar system, their mutual distances, and their velocities were to diminish proportionally, they would describe curves in all respects similar to those in which they now move.

Mechanics, in Cab. Cyc. pp. 75—79, 81—102. Astron. by Sir John Herschel, ditto, pp. 237, 389—394. System of Astron. by Margaret Bryan, pp. 22, 186—205. Connexion of the Sciences, pp. 1—7, 381, 407—409, 412. Whitehurst's Theory of the Earth, pp. 6—9. Treat. on Double Stars, by M. Arago, Edin. Jour. Science. Prof. Whewell's Bridg. Treat. pp. 214—239. Dr. Faraday's Experimental Researches, vol. ii. pp. 284—293. Chemistry, in Cab. Cyc. pp. 3, 4, 27—29. Disc. on Nat. Philos. by Sir John Herschel, in Cab. Cyc. pp. 56, 72, 255, 280. Philos. of Chemistry, by Daniel, pp. 20, 21. Architecture of the Heavens, Nichol, 1837, pp. 152, 153, 211, et seq. Mechanics, by Laplace, Toplis, pp. 52, 285, 286. New Treat. on Mechanics, London, 1841, pp. 7, 31. Phen. and Order of the Solar System, Nichol, pp. 208—281.

71. That as results of the principles mentioned in the preceding theorems, there have been deduced by Sir Isaac Newton, the followng three comprehensive rules, called the *laws of motion*, namely :—

1st. Every body must persevere in its state of rest, or of uniform motion in a straight line, unless it be compelled to change that state by forces impressed upon it.

2nd. Every change of motion must be proportional to the impressed force, and must be in the direction of that straight line in which the force is impressed.

3rd. Action must always be equal and contrary to reaction; or the action of two bodies upon each other must be equal and directed towards contrary sides.

Mechanics, in Cab. Cyc. pp. 30, 38—46. Prof. Whewell's Bridg. Treat. p. 232. Mechanics, by Laplace, Toplis, 1814, p. 2. New Treat. on Mechanics, London, 1841, p. 1.

72. That when a body has a motion of rotation, the line round which it revolves is called an *axis;* in which case every

point in the body must move in a circle whose centre lies in the axis and whose radius is the distance of the point from it. That, sometimes, when the body revolves, the axis, itself, is moveable, and, not unfrequently, in a state of actual motion; the motions of the earth and planets being examples of this kind.

Mechanics, in Cab. Cyc. p. 128, 129. New Treat. on Mechanics, London, 1841.

73. That the same causes which produce pressure on a body when restrained, will produce motion if the body be free. Accordingly, if a body be moved by any efficient cause, it will, by reason of the CENTRIFUGAL FORCE, FLY OFF; and the moving force with which it will thus retreat from the centre round which it revolves will be the measure of the centrifugal force. The following are the expression of its laws:—

1. Equal weights revolving with the same velocity at equal distances from the centre will have the same centrifugal force.

2. Equal weights with equal angular velocities, at distances from the centre in the proportion of one to two, have their centrifugal forces in the same proportion.

3. Equal weights at equal distances, with velocities as one to two, have their centrifugal forces as the square of their angular velocities.

4. Equal weights at distances as two is to three, and with velocities as one to two, have their centrifugal forces in the proportion of their respective distances multiplied by the square of their velocities. And

5. Weights which are as one to two at equal distances, with the same velocity, will have their centrifugal force increasing as the mass of the moving body increases.

Mechanics, in Cab. Cyc. pp. 98—101, 105. Mechanics, by Laplace, Toplis, pp. 49—52. New Treat. on Mechanics, pp. 73—84. Whitehurst's Theory of the Earth, pp. 9—11.

74. That to the centrifugal force, arising from the rotation of the earth around its axis, and to its greater opposition to gravity in the equatorial regions, is attributed the protube-

rance of its form in those regions: or the excess of the equatorial beyond the polar diameter. And that this opinion is corroborated by the excessive oblate form, and corresponding rotatory velocity of Jupiter. The axis of the planets in general being less than the diameters perpendicular to the axis.

Mechanics, in Cab. Cyc. p. 105, et seq. System of Astronomy, by Margaret Bryan, 1797, p. 27, et seq. Connexion of the Sciences, pp. 8, 34—36, 76. Whitehurst's Theory of the Earth, 1786, pp. 9—14. Astron. by Sir John Herschel, pp. 108—123. Phillips's Geology, p. 7. Phen. and Order of the Solar System, p. 224.

75. That forces, in general, are classed according to the duration of their action into *instantaneous* and *continued;* the effect of the former being produced in an infinitely short time. If the body which sustains it be previously quiescent and free, it will move with a uniform velocity in the direction of the impressed force; but if the body be so restrained that the impulse cannot put it into motion, then the fixed points or lines which resist the motion will receive a corresponding shock, called *percussion*, at the moment of the impulse; and which, like the force that caused it, is *instantaneous*..

A continued force will produce a continued effect, with corresponding results.

Mechanics, in Cab. Cyc. pp. 129—131. Daniel's Philos. of Chemistry, p. 15.

76. That if a point on which a force be applied is free to move in a certain direction not coinciding with the applied force, it will be resolved into two elements, one of which will be in the direction in which the point is free to move, and the other at right angles to that direction. The point will move in obedience to the former element, and the latter will produce percussion or pressure on the point or line which restrains the body.

And, that should the forces impressed on the body, whether continued or instantaneous, be such as, were it free, would communicate to it a motion, which the restraining circumstances do not forbid it to receive, then the fixed points or

lines which restrain the body sustain no force; the phenomena will be the same, in all respects, as if those points or lines were not fixed.

Mechanics, in Cab. Cyc. pp. 130, 131.

77. That if a solid body, moveable on a fixed axis and susceptible of no motion, except one of rotation on that axis, be submitted to the action of instantaneous force, one or other of the following effects must ensue:—

1st. The axis may resist the force and prevent any motion.

2nd. The axis may modify the effect of the force, sustaining itself a corresponding percussion; and the body will receive a motion of rotation; or

3rd. The force applied may be such as would cause the body to revolve round the axis, even were it not fixed; in which case the body will receive a motion of rotation, but the axis will suffer no percussion.

That the same results proceed from the application of continued forces—

1st. The axis may entirely resist the effects of continued forces, and suffer a percussion which can be estimated by the rules for the composition of forces.

2nd. It may modify the effect of the applied forces, and sustain a pressure; the body receiving a motion of rotation, subject to constant variation, owing to the incessant action of the forces, or

3rd. The forces may be such as would communicate to the body the same rotatory motion if the axis were not fixed; in which case the forces will produce no pressure on the axis.

Mechanics, in Cab. Cyc. pp. 129—132.

78. That when a solid body revolves on its axis all its parts are whirled round together, and each performing a complete revolution in the same time; consequently, the angular velocity is the same for all. The tendency of each particle to fly from the axis, arising from the centrifugal force, is resisted by the cohesion of the parts of the mass, and, in general, the

tendency is expended in exciting a pressure or strain upon the axis, whose amount depends upon the figure and density of the body and the velocity of its motion.

That the following forms of solid bodies are exempted from any strain upon the axis during rotation, namely, a globe revolving on any of its diameters, the densities being the same at equal distances from the centre; a spheroid, or a cylinder, revolving on its axis, the densities being equal at equal distances from the axis, and

That since no pressure is exerted on the axis, the state of the body will not be changed if, during the rotation, the axis cease to be fixed. The body will continue, notwithstanding, to revolve round the axis, and the axis will retain its position.

Mechanics, Cab. Cyc. pp. 129—131, 140—142.

79. That the power of a force to produce rotation is accurately estimated, not by the force alone, but by multiplying the distance of the direction of the force from the axis (called the leverage) by the force itself, the product of which is an important datum in mechanics, and is called the *moment* of the force around the axis. And, that if the *moment*, or sum of the *moments* of the forces which tend to turn a body in one direction be equal to the *moment* or sum of the *moments* of forces which tend to turn it in the opposite direction, they will mutually neutralize each other and produce equilibrium.

Mechanics in Cab. Cyc. pp. 133—136. Connexion of the Sciences, p. 82. Mechanics, by Laplace, Toplis, pp. 69, 70. New Treat. on Mechanics, London, 1841.

80. That if the force applied to a body be directed upon the axis, and at right angles to it, no rotatory motion will be produced.

If a sphere, at rest in space, receive an impulse passing through its centre of gravity, all its parts will move with an equal velocity in a straight line. And, that if the impulse does *not* pass through the centre of gravity, its particles having unequal velocities, will have a rotatory or revolving motion at the same time that it is translated in space.

Mechanics, in Cab. Cyc. p. 133. Connexion of the Sciences, p. 9.

81. That there is a certain point called the *centre of gyration*, at which, if the whole mass were concentrated, it would receive from an impulse the same velocity round the axis. And, that the perpendicular distance from the centre of gyration to the axis is termed the *radius of gyration.*

That of all axis, taken in the same body parrallel to each other, that which passes through the centre of gravity has the least *radius of gyration.* That the product of the numerical expression for the mass of the body and the square of the radius of gyration is called the *moment of inertia.* That the velocity of rotation which a body receives from any given impulse is great in exactly the same proportion as the *moment of inertia* is small.

And, that from all these principles it follows, *that a given impulse at a given distance from the axis will communicate the greatest angular velocity when the axis passes through the centre of gravity.*

Mechanics, in Cab. Cyc. pp. 136—138. Mechanics, by Laplace, Toplis, 1814, pp. 208, 209.

82. That the point of a plane where the direction of an impressed force meets it when no percussion on the axis is produced is called the *centre of percussion.*

That there are many positions of an axis which may have no *centre of percussion*—that is, there will be no direction in which an impulse could be applied without producing a shock upon the axis.

That one of these positions is when it is a principal axis passing through the centre of gravity; and as this is the only case of rotation round an axis in which the latter will sustain no pressure from the centrifugal force of the revolving mass, it follows, *that the only case in which the axis sustains no effect from the action produced is one in which it necessarily must suffer an effect from that which produces the motion.*

Mechanics, in Cab. Cyc. pp. 139—145.

83. That in Friction the amount of the resistance increases according to the roughness of the surfaces, and the

force with which these, moving upon one another, are pressed together. Surfaces being equal, a double pressure will produce a double friction. That these results are but slightly affected by the velocity with which the surfaces move upon each other.

And, therefore, any body moving under the effects of a given force will, in proportion to the increase of the asperity and pressure, be the more speedily deprived of its velocity, and reduced to a state of rest. That FRICTION is a great source of heat independently of fire or flame; and that it also excites electrical influences.

Mechanics, in Cab. Cyc. pp. 260—268. Playfair's Hutt. Theory, p. 186. Nat. Philos. by Sir John Herschel, pp. 313—330. Prof. Whewell's Bridg. Treat. pp. 238—250. Chemistry, in Cab. Cyc. p. 42. Heat, in idem, pp. 27, 385—403. Electricity, in idem, pp. 230—232, 259—261. vol. ii. p. 283. Daniel's Philos. of Chemistry, pp. 47, 60, 99—101. New Treat. on Mechanics, London, 1841, p. 2.

84. That the ATMOSPHERE is an ærial ocean surrounding the earth in all directions, and of which the surface of the land and sea forms the bed. That its density diminishes with extreme rapidity as it proceeds upwards; and, eventually, at a height not exceeding fifty miles, reaches a real and definite boundary. That this upper surface is estimated to be precisely where the specific elasticity of the air is balanced by the power of gravitation. And, that the mean temperature of space is considered to be 58° below the zero point of Fahrenheit.

Astronomy, by Sir John Herschel, Cab. Cyc. pp. 23, 26. System of Astronomy, by Margaret Bryan, 1797, p. 73, et seq. Art. by Dr. Woolaston, in Edin. Phil. Jour. No. xiii. Note, by Mr. Smith, in same period. No. xvi. p. 416. Connexion of the Sciences, pp. 121, 133—136. Chemistry, by Hugo Reid, p. 37. Dick's Christian, Philos. p. 106. Phillips's Geology, pp. 23, 24. Chemistry, in Cab. Cyc. p. 94. Heat, in idem, p. 234. Daniel's Philos. of Chemistry, pp. 33, 58, 174, 324. Nat. Philos. in Cab. Cyc. by Sir John Herschel, p. 231. Espy on Philos. of Storms, 1841. Prin. of Meteorology, by G. Hutchinson, p. 3, 4, et seq. Meteorology, by Dr. Thomson, 1849, pp. 2—27, 71, 96. Manual of Barometers, by John H. Belville, Greenwich, 1849.

85. That the ATMOSPHERE is composed of ærial fluids, chiefly oxygen and nitrogen, in the ratio of one volume of the

former to four of the latter; or, more correctly, one hundred parts of atmospheric air contain $20\frac{2}{10}$ of oxygen and $79\frac{2}{10}$ of nitrogen. It also contains variable quantities of carbonic acid gas and of aqueous vapour. That the two first of these have never either been liquidized or rendered incandescent; while the amount of moisture varies according to the dew point and state of the barometer. That although in certain states it is 815 times lighter than water, it exerts a pressure on the surface of the earth equal to 15lbs. for every square inch: a pressure which prevents the sun's rays from converting water and all other fluids into vapour. That it is permanently elastic, its tension increasing in proportion to its density; admits of considerable variation in the quantity of its associated watery vapour; and, that a gas and a vapour, occupying the same space, have a tension equal to their combined tensions.

Heat, in Cab. Cyc. pp. 220, 221. Connexion of the Sciences, p. 133, et seq. Chemistry, by Hugo Reid, pp. 28—83. Dick's Christian Philos. pp. 107, 108. Prof. Whewell's Bridg. Treat. pp. 96—110. Chemistry, in Cab. Cyc. pp. 99, 103, 145—151. Heat, in idem, pp. 167, 177, 179, 356. Daniel's Philos. of Chem. pp. 33, 42, 76, 308, 314—316, 318, 319, 338, 349. Espy on the Philos. of Storms, 1841. Prin. of Meteorology, by G. Hutchinson, pp. 4, 5, et seq. Meteorology, by Dr. Thomson, 1849, pp. 2—18, 23, 24. Manual of Barometers, by John H. Belville, Greenwich, 1849.

86. That every gas has, at least, two ingredients in its composition, namely, some gravitating matter, which may be called its base or principal part, and the subtile fluid, caloric or heat, and perhaps light and electricity; which, when present in sufficient quantity, cause the base or radicle to appear in a gaseous form.

Chemistry, by Hugo Reid, pp. 101, 102. Brooke's Elements of Crystallography, p. xlix. Chemistry, in Cab. Cyc. p. 52.

87. That, with respect to the oxygen and nitrogen gases of the air, although the expansive principle acts powerfully in repelling from each other the particles of the same gas, it does not act between those of different gases.

That by the "diffusion principle of gases" when two are put together they will finally be arranged as if each occupied

the whole space and the other was not present; the heavier being caused to ascend, and the lighter to descend.

That this is the case with the gases of the atmosphere, and that there seems to exist a power acting upon permanent gases capable of counteracting, to a certain extent, the effects of the attraction of gravitation, and thereby forming an exception to what has hitherto been considered a universal law.

Chemistry, by Hugo Reid, pp. 28—83. Daniel's Philos. of Chem. pp. 73—76. Chemistry, in Cab. Cyc. pp. 146—151. Heat, in idem, pp. 187, 188. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. p. 3, et seq.

88. That when a space is filled with a mixture of gas and vapour, these two bodies act, under changes of volume, in exactly the same manner as they would if each separately occupied the whole space; the gas dilates and contracts, changing its pressure and temperate with its density.

The vapour obeys the same law, so long as no part of it is condensed into a liquid; but as compression renders condensation more easy by the more rapid development of heat, when much compression is used, a portion of that caloric necessary to maintain the vapour in the æriform state will escape. A corresponding quantity of the vapour will become liquid; and the remainder will be mingled with the gas, having the same tension which it would have if the gas were not present.

Heat, in Cab. Cyc. pp. 221, 225, 226. Prof. Whewell's Bridg. Treat. pp. 86—88, 96—110. Daniel's Philos. of Chem. pp. 73—75. Meteorology, by Dr. Thomson, 1849, pp. 7, 97, et seq.

89. That a Liquid is a body, in which the attraction of cohesion is so far overcome as to admit of its yielding to the slightest pressure; and of the particles easily changing their relative position with respect to one another without separating the mass, or repelling each other as those of æriform substances do. That fluids have a direct tendency to find and maintain their level, owing to the combined results of gravitation (whereby each particle is attracted to the centre of the earth) and the perfect mobility of the particles among themselves. And that liquids possess the property of transmitting

pressure on every direction, each pressing equally on all the particles that surround it, and being equally pressed upon by them.

Disc. on Nat. Philos. by Sir John Herschel, pp. 231—234. Hydrostatics, in Cab. Cyc. pp. 4—12, 26—30, 52. Connexion of the Sciences, pp. 118, 119. Chemistry, by Hugo Reid. Mechanics, by Laplace, Toplis, 1814, p. 125, et seq.

90. That in every fluid the particles which are beneath sustain the pressure of those above them in proportion to their perpendicular depth, uninfluenced by the size or shape of that which contains the fluid. That the pressure exercised by water is estimated at nearly one pound on each square inch for every two feet of depth. And, that of all the various states of liquidity, WATER is that which has become the general type; and to which all others are referred.

Hydrostatics, in Cab. Cyc. pp. 23—29.

91. That the great *Reservoir* of WATER, from which all other kinds are, in the first instance, derived, is the ocean, which, extending over three-fourths of the surface of the globe, affords an inexhaustible supply.

That, by repeated analyses, sea water has been found to consist of the following ingredients in every 500 grains, namely:—

478.420 of pure water
13.300 muriate of soda, or culinary salt
2.333 sulphate of soda
0.995 muriate of lime
4.955 muriate of magnesia

Wherefore, the ocean, besides the elements of pure water,* contains muriatic and sulphuric acids, soda, magnesia, and lime, together with traces of iodine, bromine, and, occasionally, potash. That its specific gravity is to that of pure water as 1.0277 is to 1. And that the solution of salts or of acids in water increases the power of that liquid for the transmission respectively of heat, or of the electric fluid.

Chemistry, by Hugo Reid, pp. 115—120. Connexion of the Sciences,

* 1 part hydrogen, 8 parts oxygen.

pp. 227, 228, 230, 231. Geol. by de la Beche, p. 3. Prof. Buckland's Bridg. Treat. vol. i. p. 557. Prof. Whewell's Bridg. Treat. p. 53. Chemistry, in Cab. Cyc. pp. 122—125. Heat, in idem, pp. 200, 251. Daniel's Philos. of Chem. pp. 319, 372, et seq. Prin. of Meteorology, by Hutchinson, p. 17, et seq. Meteorology, by Dr. Thompson, 1849, Introduction.

92. That the water of the Caspian Sea, the Lakes of America, and of most other natural inland reservoirs of the world, is fresh; and not saline like that of the ocean.

Any geographical work.

93. That the watery vapour of the atmosphere is due to the influence of HEAT; which, infusing the repulsive principle into the waters of the seas, rivers, and lakes, causes them to ascend in an æriform state.

That the ocean undergoes a continual process of evaporation, and dismisses into the atmosphere a quantity of pure water, proportionate to its extent of surface, to the temperature of the air, and to its state of saturation.

That whenever the temperature of the air is reduced below the limit at which the suspended vapour is maintained in a state of saturation, condensation takes place, and rain or aqueous clouds are produced.

And, that by these alternate processes the terraine surface of our globe is supplied with fresh moisture and with water necessary to sustain the organization, and to maintain the functions of the animal and vegetable kingdoms.

Chemistry, by Hugo Reid, pp. 53, 115—117. Lyell's Prin. of Geol. vol. i. p. 269. Prof. Whewell's Bridg. Treat. pp. 53, 87, 96—110, 211—214, 228—235. Heat, in Cab. Cyc. pp. 211—214, 228—235, 249, 250. Prof. Buckland's Bridg. Treat. vol. i. p. 557. Espy on the Philos. of Storms, 1841. Vindiciæ Geol. p. 13. Phillips's Geol. p. 13. Chem. in Cab. Cyc. p. 150. Daniel's Philos. of Chem. pp. 149, 156, 160. Prin. of Meteorology, by G. Hutchinson, pp. 9—18, et seq. Manual of Barometers, by Belville, Greenwich, 1849. Meteorology, by Dr. Thomson, 1849, p. 97, et seq.

94. That the following seem to be the most obvious principles, whose combinations and mutual action on each other

govern and modify the meteorological state of the atmosphere, namely:—

The existence of a *constituent temperature* for the maintenance of water in a state of vapour. The opposite tendencies of *air* from the colder to the warmer parts; and of *vapour* from the warmer to the colder parts of the atmosphere and terraqueous surface. The different rates at which the temperature and tension of air and of vapour decrease as they ascend from the surface of the earth or sea. The different capacities for heat of those two component parts of the earth's surface. And, lastly, the unequal distribution of the electric fluid in the nephalic masses of the atmosphere, and its tendency to a state of equilibrium.

Prof. Whewell's Bridg. Treat. pp. 86—112. Whitehurst's Theory of the Earth, 1786, p. 148, et seq. Daniel's Essay on Meteorology. Phillips's Geol. p. 13. Heat, in Cab. Cyc. pp. 65, 211—214. Daniel's Philos. of Chem. pp. 157, 286. Espy on the Philos. of Storms, 1841. Prin. of Meteorology, by Hutchinson, Intro. Manual of Barometers, by Henry Belville, Greenwich, 1849. Meteorology, by Dr. Thomson, Glasgow, 1849.

95. That the Vaporization of a *Fluid* is accelerated by the increase of its temperature, and more so when heat is applied to a surface free from external pressure; in a vacuum vaporization is almost instantaneous. The agitation of the surface likewise increases the effect. That, in general, the rate of evaporation from the surface of the water, in all states of the atmosphere, will be proportioned to the tension of vapour which would saturate the atmosphere, diminished by the tension of the vapour actually in the atmosphere.

And that, as different substances are subject to vaporization at different temperatures, this peculiarity is frequently employed in chemistry and the arts as an efficacious method of precipitating solutions by separating them from the water with which they are combined.

Chemistry, by Hugo Reid, p. 53. Connexion of the Sciences, pp. 241, 242, 248, 250. Heat, in Cab. Cyc. pp. 18, 146—149, 154—175, 200—223, 227—232, 238—244, 263. Prof. Whewell's Bridg. Treat. pp. 86—88. Prin. of Meteorology, by Hutchinson, pp. 26, 89, et seq. Chemistry, Cab. Cyc. p. 150. Daniel's Philos. of Chem. pp. 139—141,

149—151, 154, 318, 319. Espy on the Philos. of Storms, 1841. Meteorology, by Dr. Thomson, 1849, p. 97, et seq.

96. That the comparatively feeble affinity of WATER for bodies—which is sufficient merely to dissolve them without materially altering their properties or retaining them in too firm chemical union—constitutes one of its chief advantages: various solid bodies, when dissolved, manifesting properties which would not otherwise have been discovered; but by its means, the cohesion of their particles being overcome, and being, by this simple carrier (water), brought into close and universal contact of their particles, they are rendered more capable of chemical combination.

That *Water*, by its dissolving power, enables one substance to be separated from another, or from a number of other bodies with which it may be associated. And that the properties of water, with relation to light, heat, and electricity, render it the fittest agent which can be employed in conducting chemical operations.

Chemistry, by Hugo Reid, pp. 109—111, 139. Phillips's Geology, p. 202. Chemistry, in Cab. Cyc. pp. 7, 364, 389—391. Heat, in Cab. Cyc. pp. 348, 387. Hydrostatics, in Cab. Cyc. p. 3. Daniel's Philos. of Chem. pp. 69—71, 129, 319, 441, 450, 525—532. Electricity, in Cab. Cyc. vol. ii. p. 392. Prin. of Meteorology, by Hutchinson, p. 160, et seq. Connexion of the Sciences, pp. 227, 231. De Luc's 2nd and 3rd Letters. Pop. Hist. of Brit. Algæ, pp. 60—62.

97. That geologists generally concur in the opinion that the sea is the residium of a primitive ocean, which, at one time or other, seems to have covered the dry land which now constitutes the habitable surface of the globe. That from it were deposited the mineral ingredients which compose the inorganic portion of the stratiform masses of the earth. That this separation simultaneously prepared the primitive ocean for becoming the present sea. And, lastly, it has been maintained, especially by some of the earlier geologists, "That there are no operations now taking place in the sea, which bear the slightest analogy to those productions of mineral substances in strata which took place formerly on our globe."

Phillips's Geology, pp. 54, 95, 207. Whitehurst's Theory of the

Earth, 1786, pp. 15—27, 86. Chemistry, by Hugo Reid, p. 120. Letter by Dr. Fleming, in Edin. Philos. Jour. No. xv. p. 121. Geol. by Dr. M'Culloch, vol. i. p. 497. Vest. of Creation, p. 73. Fowne's Actonian Prize Essay. Daniel's Philos. of Chem. pp. 445, 446. De Luc's Letters. Ancient World, by Ansted, 1847, p. 108, et seq.

98. That EARTHY MATTER consists generally of some metallic substance in chemical combination with oxygen, forming an oxide. That the combination of earthy metals with oxygen usually takes place when favoured by a sufficient elevation of temperature. That this constitutes the important change which many metals undergo when heated under exposure to the air. And that, to facilitate this combination, it is necessary to raise their temperature considerably, to some metals it being even requisite to apply very intense heats.

Chemistry, by Hugo Reid, p. 144. Brooke on Crystallography, pp. xlviii. liv. Chemistry, by Dr. J. Murray, vol. ii. pp. 123, 124. Chem. in Cab. Cyc. pp. 115—120. Electricity, in Cab. Cyc. p. 179. Daniel's Philos. of Chemistry, p. 420, et seq.

99. That the great mass of mineral matter which constitutes the crust of the globe is composed of the following substances, namely:—

1. Silex, or flinty earth; 2. Alumina, or earth of clays; 3. Lime; 4. Magnesia; 5. Soda; 6. Potash; 7. Iron, chiefly as an oxide; 8. Baryta; 9. Strontia; 10. Glucina; 11. Yttria; 12. Thorina; and 13. Zirconia.

Chemistry, by Hugo Reid, pp. 147—167. Dr. Ure's Chem. Dict. pp. 408, 409. Elements of Chem. by Dr. Murray, vol. ii. pp. 64—68, 123—125. Geol. by Dr. M'Culloch, vol. i. p. 194. Prof. Buckland's Bridg. Treat. vol. i. p. 69. Prof. Phillips's Geol. pp. 27—29, 45, 46. Lyell's Elements of Geol. vol. i. p. 22. vol. ii. pp. 196—211, 226—333. Heat, in Cab. Cyc. p. 126. Chemistry, in idem, pp. 115—120. Electricity, in idem, pp. 172—179.

100. That LIME is never found pure in nature; but exists always in chemical combination with other substances, chiefly carbonic acid, in which state it is so abundant as to compose about 1-8th of the entire crust of the globe. It is also very abundant as a sulphate; as a phosphate it constitutes 86 per cent of the bones of animals and of men. And in various saline

combinations, especially as a muriate, it exists in the waters of the ocean, in that of springs, and in vegetable and animal matter. It is considered by many to be the product of animal secretion. And possesses the singular quality of being much more soluble in *cold* than in *hot* water.

Murray's Elements of Chem. vol. ii. pp. 81—89. Chemistry, by Hugo Reid, pp. 105, 150, 155—157. Dr. Ure's Chem. Dict. pp. 246, 247. Brooke's Crystall. pp. xlix.—lvii. Geol. by Dr. M'Culloch, vol. i. pp. 202, 216, 221, 237. vol. ii. pp. 256, 257, 262, 413. Prof. Buckland's Bridg. Treat. vol. i. p. 577. Lyell's Elem. of Chem. vol. 1. p. 23. Chem. in Cab. Cyc. pp. 32, 118, 119.

101. That by experiment it has been proved, that if carbonate of lime be heated under a pressure equal to 1,700 feet of sea water; or to a column of liquid lava 600 feet high, so as to prevent the escape of its carbonic acid, it may be melted at a temperature even not higher than 22° of Wedgewood's scale. That by this process it acquires considerable hardness and closeness of texture, approaching, in these qualities, as well as in fracture and specific gravity, to the finer kind of limestone or marble. And latterly it has been discovered, that even without compression carbonate of lime may be fused by the sudden application of violent heat, or by submitting it to heat in a large mass.

Lyell's Prin. of Geol. vol. iii. p. 370. Elem. of Chem. by Dr. Murray, vol. ii. p. 85. Dr. Buckland's Bridg. Treat. vol. i. p. 41. Lyell's Elem. of Geol. vol. i. p. 106. vol. ii. pp. 258—260, 406. Phillips's Geol. pp. 76, 259. Disc. on Nat. Philos. by Sir John Herschel, pp. 269, 270.

102. That CARBONIC ACID abounds in nature, and appears to be produced under a variety of circumstances. It composes 44-100ths of the weight of limestone, marble, calcareous spar, and other natural varieties of calcareous earth. That on the application of a pretty strong heat to the various kinds of limestone (carbonate of lime), the carbonic acid is evaporated and the *lime* remains.

And, that the basis of all effectual cements used in constructing works designed to be either occasionally or permanently under water, must be made from the hydrate of lime.

Dr. Ure's Chem. Dict. pp. 25—27, 585. Chemistry, by Hugo Reid,

pp. 151—157. Lyell's Elem. of Geol. vol. i. pp. 25, 26. Chem. in Cab. Cyc. pp. 33, 118, 119, 257. Optics, by Sir D. Brewster, Cab. Cyc. p. 144. Daniel's Philos. of Chem. pp. 326, 356.

103. That *Quartz* consists almost entirely of silica, with a little alumina and oxide of iron.

That *Felspar* in 100 has 63 parts of silica, 17 alumina, 13 potash, 3 of lime, and 1 oxide of iron.

That *Mica* is composed of 46 parts of silica, 31 of alumina, 8.50 potash, 8.50 oxide of iron, 1.50 oxide of manganese, the remainder fluoric acid and water. That *Hornblend* has silica 42, alumina 12, oxide of iron 30, lime 11, magnesia 2.25, and the rest manganese.

That *Steatite* consists of 64 parts silica, magnesia 22, water 5, and oxide of iron 3. That common *Limestone* is composed of 56 parts of lime and 44 of carbonic acid. That *Earthy Chlorite* has 43 per cent. oxide of iron, 26 of silica, 18 of alumina, magnesia 8, and muriate of soda 2 per cent. That *Gypsum* (selmite) consists of 33 parts lime, 46 sulphuric acid, and of water 21 parts ; and that *Rock Salt* contains in 1,000 parts, 983 of muriate of soda, 6 parts sulphur of lime, the remainder being insoluble matter.

From which analyses it is obvious that silica, alumina, lime, magnesia, potash, soda, and the oxides of iron and manganese are, by far, the most abundant ingredients in the rocky parts of the earth, appearing to compose about 99-100ths of the entire mass of the outer crust of our planet. Whilst baryta, strontia, glucina, yttria, zirconia, and thorina, though occasionally found, are thus shown to be of comparatively rare occurrence.

Chemistry, in Cab. Cyc. pp. 33, 115, 120, 232. Lyell's Elem. of Geol. vol i. pp. 90, 381. vol. ii. p. 205, and tables, pp. 210, 328, 381. Chemistry, by Hugo Reid, pp. 147—157. Phillips's Geol. pp. 25—29. Brooke's Crystall. pp. xlviii.—lxiv.

104. That, in order to form a just idea of Soil—which consists of small stones and sand, impalpable earthy matter, decaying animal and vegetable substances, and small quantities of salts—it is necessary to conceive different rocks to be

decomposed and ground to fineness, some of their soluble parts dissolved in water, and that water adhering to the mass, and the whole mixed with the remains of vegetables and animals in different stages of decay, together with small portions of salts; the earthy matter, however, constituting their chief proportion. And that, when the mineral ingredients of soils are traced to their ultimate elements, they are found to consist chiefly of silica, alumina, magnesia, and the oxides of iron and of manganese.

Chemistry, by Hugo Reid, pp. 158—167. Dr. Ure's Chem. Dict. pp. 156—161, 736, 757—759. Whitehurst's Theory of the Earth, pp. 217—219. Geology, by Dr. M'Culloch, vol. i. p. 11. Agricult. Chemistry, by Sir H. Davy. Prof. Buckland's Bridg. Treat. vol. ii. pp. 69, 70. Lyell's Elem. of Geol. vol. ii. p. 188. Vindiciæ Geol. p. 17. Chemistry, in Cab. Cyc. pp. 115—120. Botany, in idem, pp. 176, 299.

105. That METALLIC ORES—which are metals in combination either with sulphur, charcoal, oxygen, and even with other metals, or with silica, alumina, and lime—are commonly found in narrow fissures, termed lodes or veins, predominating in the primitive and transition series, and which are usually filled up with some crystalline mineral different from the rock in which they occur.

That they are supposed to have been produced by electrical agency developed by the violent contact and friction of rocks of various kinds containing, previously, metalliferous elements. And, that the same lode frequently contains a metallic pyrite, and, within a short distance, separated merely by a common argillaceous substance, some other modification of the same metal, whilst the lode itself is generally saturated with water containing various salts.

Lyell's Elem. of Geol. vol ii. pp. 342, 363. Werner on Veins. Transactions of Brit. Asso. at Bristol, 1836, Lit. Gazette. Prof. Buckland's Bridg. Treat. vol. i. p. 548—553. vol. ii. p. 108. Prof. Whewell's Bridg. Treat. p. 114. Chemistry, by Hugo Reid, p. 166. Phillips's Geol. pp. 111, 112. Electricity, Cab. Cyc. pp. 169—172. Daniel's Philos. of Chemistry.

106. That when a general view is taken of METALLIC VEINS on any geological map, the following prominent and

characteristic features present themselves to the observation, namely :—

1. That they either entirely originate from, or predominate in the primary masses and the transition series.

2. That, generally, they run in straight lines and in directions oblique to the surface; veins of different materials cutting each other at right angles, and, not unfrequently, perpendicular to the lines of stratification.

3. That, unlike *faults* and *dykes*, *mineral veins* do not cause dislocation of the strata; but seem, whilst they have evidently passed through, to have left them undisturbed in their relative positions. And

4. That when veins cut each other at right angles they are usually different in their contents.

Prof. Buckland's Bridg. Treat. vol. i. pp. 458—555. vol. ii. pp. 147—149, map and notes. Lyell's Elem. of Geol. vol. ii. on metals in veins. Phillips's Geol. pp. 84, 91, 111, 112, 263—276. Vindiciæ Geologici, pp. 18—21. Geology, by H. T. de la Beche, pp. 521—524.

107. That Coal—of which there are two principal species, black and brown, and several sub-species, all varying in the proportion of their elementary constituents—is generally admitted to be of *vegetable* origin; and, although consisting essentially of carbonaceous matter, yet there is frequently present a soft, bituminous substance which communicates to it peculiar properties. That, on being distilled, it affords a considerable quantity of ammonia. And it is thought that pressure and the continued action of water have been the principal agents in transforming the original vegetable matter into bituminous coal.

Dr. Ure's Chem. Dict. pp. 339—341. Chem. by Hugo Reid, p. 157. Prin. of Geology, by Lyell, vol. ii. p. 216. Botany, in Lib. Useful Know. Murray's Elem. of Chem. vol. ii. p. 368. Vestiges of Creation, p. 80. Botany, by Prof. Henslow, Cab. Cyc. p. 310. Geol. by Dr. M'Culloch, vol. ii. pp. 350—353, 358, 414. Prof. Buckland's Bridg. Treat. vol. i. pp. 64, 454—459. Lyell's Elem. of Geol. vol. ii. pp. 106, 279—281.

108. That Native Salts, such as saltpetre *(nitrate of potash)*, green vitriol *(sulphate of iron)*, rock salt *(muriate of soda)*, sal ammonia *(muriate of ammonia)*, borax or tincal

(biborate of soda), alum *(sulphate of alumina and potash)*, and natron *(carbonate of soda)*, are found fossil in the earth in regular and symmetrical crystalline forms. And, that they yield rapidly to any force applied to them, and are capable of being fused by heat.

Chemistry, by Hugo Reid, p. 142. Dr. Murray's Elem. of Chemistry, vol. ii. pp. 289—291. Mineralogy, by Prof. Jamieson, vol. iii. pp. 1—45. Murchison's Geol. Invest. in Russia, Poland, &c. Chemistry, in Cab. Cyc. p. 114. Daniel's Philos. of Chemistry.

109. That in chemical language ALKALIES are bodies which, besides possessing other minor properties, combine with acids, so as to neutralize and impair their activity. That METALLIC OXIDES are metallic substances combined with oxygen without being in a state of an acid. That the characteristic and indispensable property of an *Acid* is to unite in definite proportions with the *Alkalies*, *Earths*, and *Metallic Oxides*, and form thereby the important class of substances called *Salts*. That "*a salt*," therefore, denotes a compound in definite proportions of acid matter with an alkali, earth, or metallic oxide; and that the carbonates, sulphates, muriates, &c., of soda, lime, and magnesia, &c., are formed by the union of these acids with the basis which give them their respective denominations.

Dr. Ure's Chem. Dict. pp. 5, 135, 673, 709, et. seq. Dr. Murray's Elem. of Chem. vol. ii. p. 70, et seq. Chemistry, by Hugo Reid. Chemistry, in Cab. Cyc. pp. 101, 109—113, 121. Daniel's Philos. of Chemistry, pp. 431, 445—449.

110. That besides pure water the most common ingredients in mineral springs are carbonic acid, sulphuretted hydrogen, carbonates, sulphates, and muriates of soda, of lime, and of magnesia, and carbonate and sulphate of iron. And those of more rare occurrence are sulphurous acid, nitrogen gas, sulphate of alumina, muriate of manganese, siliceous earth, fluoric acid, lithnia, strontia, potash, and hydriodic acid.

That as mineral contents are in chemical solution, they rarely, even when in great abundance, affect the clearness of the water. That to hold a large quantity of silex in solution, it seems requisite that the water should be raised to a high

temperature. And that, notwithstanding their mineral character and the high temperature of some of the springs, confervee and other plants thrive in and close around them.

Dr. Murray's Elem. of Chemistry, vol. ii. p. 376. Chemistry, by Hugo Reid, pp. 133—137. Lyell's Prin. of Geol. vol. i. pp. 227—243. Geol. by H. T. de la Beche, pp. 139—147. Botany, by Prof. Henslow, Cab. Cyc. p. 173. Lyell's Elem. of Geol. vol. i. pp. 67, 89, 381. vol. ii. p. 407. Phillips's Geology, p. 147. Gardiner's Essay on Mineral and Thermal Springs.

111. That when substances are rendered fluid, with perfect mobility amongst their particles, either by igneous fusion or by solution, and are suffered to pass with adequate slowness into the solid state, the attractive forces—called homogenous attraction—frequently re-arrange these particles into regular polyhedral figures or geometrical solids; to which the name of CRYSTALS has been given. That mere approximation of the particles is not, however, alone sufficient to produce *crystallization*, they must also change the direction of their poles from the fluid colocation to their position in the solid state, which may be effected by the following means, namely :—

1. By vibratory motion, communicated either from the atmosphere or any other moving body.

2. By contact of any part of the fluid with a point of a solid of similar composition previously formed, or other substance.

3. By the slow and continued agency of voltaic electricity operating in water.

That darkness, in most instances, favours crystallization.

That heat, likewise, exercises considerable influence on these phenomena; and, lastly, that the same substance, in crystallizing, not unfrequently assumes a diversity of forms; though, in general, the same substance, under similar circumstances, assumes the same form.

Disc. on Nat Philos. by Sir John Herschel, pp. 239—246, 290—293. Lyell's Elem. of Geol. vol. i. pp. 76—89. vol. ii. 390—400. Daniel's Philos. of Chem. pp. 78—99, 603. Chemistry, in Cab. Cyc. pp. 17—19. Heat, in idem, pp. 195—199. Brooke on Crystallography. Prof. Buckland's Bridg. Treat. vol. i. p. 36. Vestiges of Creation, p. 170. Connexion of the Sciences, pp. 124—128, 312. Dr. Ure's Chem. Dict. pp. 379, 380. Transactions of Brit. Asso. Sept. 1836. Electricity, in

Cab. Cyc. vol. ii. pp. 379—386. Botany, in Cab. Cyc. p. 6. Mechanics, in Cab. Cyc. pp. 14, 15.

112. That most of the rocks which compose the mineral crust of the earth are in a crystallized state. *Granite*, for example, consisting of crystals of quartz, felspar, and mica ; *Marble* of crystals of carbonate of lime, &c. And that the whole phenomena attendant on crystallization go to prove that substances having the same crystalline form must consist of ultimate atoms, having the same figure and arranged in the same order, so that the form of crystals is dependant on their atomic constitution.

Geology, by H. T. de la Beche, pp. 486—511, et seq. Lyell's Elem. of Geol. vol. ii. pp. 390—400. Geology, by Dr. M'Culloch, vol. i. pp. 122, 123. Brooke on Crystallography, pp. xlviii.—lxiv. Dr. Ure's Chem. Dict. pp. 379—381. Connexion of the Sciences, pp. 124—128. Chemistry, by Hugo Reid, pp. 147—157. Prof. Buckland's Bridg. Treat. vol. i. pp. 574—579. Heat, in Cab. Cyc. p. 186. Daniel's Philos. of Chem. p. 78, et seq. Prof. Phillips's Treatise, pp. 69—80.

113. That ever since Botany has merited the name of a science there has been a difference in the opinions of its followers as to the principles which ought to govern the systematic classification of the interesting objects to which it relates. And even in the present day, while the *Linnæan* and *natural* methods mutually diffuse light on each other, they resist a thorough and cordial reconciliation. That the *Linnæan* system is founded chiefly on the leading distinctions of *phanogamous* and *cryptogamous* construction, and the varied relations of certain parts of the floral organs of the former division ; whilst the *natural* system is based not only on these characteristics, but, likewise, on a comparison of the internal structure, nutritive organs, method of vegetation, and seeding processes of the various plants composing the vegetable kingdom, all of which are, by it, resolved into three classes, namely : Acotyledous, Monocotyledous, and Dycotoledous.

Botany, by Prof. Henslow, Cab. Cyc. pp. 30, 136—155. Flora Scotica, by Sir William Jackson, Hooker. Botany, in Pop. Encyclo. pp. 638—640. Botany, in Lib. Useful Know. pp. 14—18. General Review of Living Beings, Edin. Jour. Nat. Hist. p. 18.

114. That the ACOTYLEDONOUS or CRYPTOGAMOUS CLASS includes an extensive series of plants, grouped under several ORDERS, differing considerably in many paticulars, but the whole agreeing in the important circumstance of *never bearing flowers*. That, having no flowers, they produce no true seeds, but, in lieu thereof, the higher tubes are furnished with minute gravular bodies, capable of becoming distinct plants, called sporules; not separable into distinct parts with radicle, plumule, and cotyledons, like the seeds of phanogamous plants.

That these sporules possess the power of producing from any part, either stem or root, as circumstances may require, while it is quite otherwise with true seeds. That acotyledonous plants increase acrogenously, and, as a class, they consist of the following orders, namely :—

I. Fungi; II. Lichens; III. Algæ; IV. Characeæ; V. Hepaticeæ; VI. Musci; VII. Filices; VIII. Lycopodineæ; IX. Marcilaceæ; and X. Equisetaceæ.

Flora Scotica, by Hooker, part ii. pp. 3—161. Botany, by Prof. Henslow, Cab. Cyc. pp. 11, 17, et seq. Botany, in Lib. Useful. Know. p. 108. Edin. Review, No. xcix. p. 154. Connexion of the Sciences, p. 456. General Review of Living Beings, Edin. Jour. Nat. Hist. p. 18. Philos. of Plants, by Decandolle and Sprengel. Prof. Buckland's Bridg. Treat. vol. ii. p. 453. Lyell's Elem. Geol. vol. i. p. 67. De Luc's Letters, pp. 110, 157, et seq. Pop. Hist. Brit. Algæ, by Dr. Landsborough.

115. That considerable difference of opinion prevails respecting the classification of the CRYPTOGAMIC plants, owing to the great dissimilarity between the higher and the lower tribes of the class. The former—contained in the division "Ductalosæ"—having green expansions, much resembling leaves in their general appearance, and possessing stomata, but differing from them in other respects, especially in bearing the fructification upon their fronds; whilst the lower tribes of cryptogamic plants—included in the group called "Cellulares"—are homogenous in their structure, with nutrative organs not distinguishable into roots and leaves, and many of them parasitic; seldom green and without stomata.

Botany, by Prof. Henslow, Cab. Cyc. pp. 27, 76, et seq. Mosses, by

Dr. George Gardiner, 1839. Classification, by Sir William Hooker, compared with those by Decandolle and Sprengel, and by M. Cuvier.

116. That in the MONOCOTYLEDONS—consisting of several orders—there is no distinction between the pith, the wood, and the bark, but their stems consist, generally, of a cylindrical, though sometimes of an angulated mass of cellular tissue, in which are bundles of vascular tissue without medullary rays. That they are called *Endogence*, from the newly-formed material developing itself towards the innermost part of their stems. That an albuminous mass forms the main bulk of most of the monocotyledonous seeds, having the embryo placed within it; the general character of these seeds being that of a cylindrical body tapering towards the extremities, from one of which, in due time, protrudes the radicle, and from the other arises a single, conical, and almost solid cotyledon.

Flora Scotica, by Sir W. J. Hooker, pp. 161—194. Botany, by Prof. Henslow, in Cab. Cyc. pp. 33, 43, 49, et seq. Botany, in Lib. Useful Know. pp. 9—24, 55—57. Smith's Intro. to Botany, p. 59. Edin. Jour. Nat. Hist. p. 18. Philos. of Plants, by Decandolle and Sprengel. Prof. Buckland's Bridg. Treat. vol. ii. p. 453. Connexion of the Sciences, p. 282.

117. That the DICOTYLEDONOUS CLASS is distinguished by the existence of pith in the centre of the stem, by increasing *exogenously*, that is, by fresh material being yearly arranged externally between the former wood and bark, and by medullary rays proceeding from the centre to the circumference of their woody parts.

That the seeds are furnished with two fleshy lobes called "*Cotyledons*" attached to a rudimentary germ concealed between them; the cotyledons during the first stages of germination becoming imperfect leaves to protect the plumule and to nourish the young plant until the radicle be developed into a root; and, finally, that this natural order comprises the more perfect plants and trees, and those whose internal structures and component tissues are most complex.

Flora Scotica, by Sir. W. J. Hooker, pp. 194—297. Botany, by Prof. Henslow, Cab. Cyc. pp. 31—33, 43, 62, et seq. Botany, in Lib. Useful Know. pp. 9—24, 55. Edin. Jour. of Nat. Hist. p. 18. Philos. of

Plants, by MM. Decandolle and Sprengel. Prof. Buckland's Bridg. Treat. vol. i. p. 453. Connexion of the Sciences, p. 282.

118. That all the phenomena attending the flowering of plants, and the dihescence of the various receptacles which are instrumental in the fertilization and maturation of the *seed* and *fruit*, and the dissemination of the former, fully attest the absolute necessity of *these complicated operations being conducted in atmospheric air;* the presence of much moisture being prejudicial to the peculiar development of the pollen.

Botany, by Prof. Henslow, Cab. Cyc. pp. 50, 79—110, 195, 263—268, et seq. Botany, in Lib. of Useful Know. pp. 38—42, 108. Prof. Whewell's Bridg. Treat. pp. 19, 23—25, 27, 47—49, 51. Any other Botanical Treat. Nat. Syst. Hunt on Light, pp. 181—202. Lindley and Hutton's Fossil Flora, vol. i. p. xv. Pop. Hist. Brit. Algæ, by Rev. Dr. Landsborough, 1849.

119. That immediately after the flower has become fully expanded, some portions of it begin to decay; but the ovarium and sometimes the calyx, and other parts continue to grow, and assume a very different appearance—they become the FRUIT; while the ovula, having been subjected to the fertilizing influence of the pollen, also undergo certain remarkable changes, and become the SEED.

That these fruits, thus enclosing their seeds, assume a great variety of forms and characters, some being soft and pulpy, others hard, woody, dry, and membranaceous; but, in general, they may be classed under some one or other of the following denominations, namely:—the legume; the drupe; the nut; the akenium; the glans; capsule; gourd; berry; pome; samara, or the siliqua.

Botany, by Prof. Henslow, Cab. Cyc. pp. 102—109. Botany, in Lib. Useful Know. pp. 47—52. Any other Treatise on Botany, or on Horticulture.

120. That, according to the opinions of the most eminent botanists, it is light, heat, water, and air, and the conjoint action of the first three of these upon the irritable membranes, which enable plants, by virtue of their extensibility, elasticity, and hygrometrical powers to perform the phenomena of con-

traction and endosmose; by means of which they absorb and digest their food, circulate their fluids, develope their organs, increase in size, and reproduce themselves.

Botany in Cab. Cyc. by Prof. Henslow, pp. 170—184, 190—203, 293—295, 298. Botany, in Lib. Useful Know. pp. 81, 84. Prof. Whewell's Bridg. Treat. pp. 115, 116. Daniel's Philos. of Chem. pp. 460—462. Connexion of the Sciences, p. 279. Hunt on Light, p. 200. Lindley and Hutton's Fossil Flora, vol. i. p. xv. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. p. 13, et seq.

121. That the time required to admit of plants arriving at maturity varies from some months to several years. And that vegetation exerts a conservative influence in protecting land from denudation by water, it being well known that a covering of herbage and plants protects a loose soil from being carried away by heavy rains, or even by the ordinary action of a river.

Botany, by Prof. Henslow, in Cab. Cyc. pp. 238, 239. Prin. of Geol. by Mr. Lyell, vol. ii. pp. 204—209. Prof. Whewell's Bridg. Treat. p. 27.

122. That of all organized substances plants are, perhaps, the most susceptible of modification in their nature and characteristic properties by the influence of climate, soil, and other circumstances.

"A bitter maritime plant having, by these means, been metamorphosed into two distinct species of garden vegetables as unlike each other as each is to the parent plant."

That although these are extreme cases, and not strictly within the limits of causes purely natural, where extent of change has a more restricted limit, still it is admitted that considerable alterations can be effected on plants in a state of nature by modifications of soil and climate.

Prin. of Geol. by Mr. Lyell, vol. ii. pp. 32—36, 50. Botany, in Cab. Cyc. by Prof. Henslow, pp. 120, 294, 309. Old Red Sandstone, Miller, Edin, 1841, pp. 39, 40.

123. That roots and seeds will not vegetate unless they be placed only at a limited depth beneath the surface of the ground. That the roots and stems of almost all plants develope themselves in opposite directions—the latter having a tendency to grow *upwards*, whilst the former goes *downwards*.

And that there can be no doubt but a direct connexion exists between "gravity" and "light;" and these tendencies which the roots and stems of plants, generally, manifest of growing in opposite directions.

Botany, by Prof. Henslow, in Cab. Cyc. pp. 10, 280—293. Chemistry of Nature, by Hugo Reid. Turner's Sacred History, pp. 127—135, founded on Mr. Porteun's assertion.

124. That, besides the carbonic acid elaborated by plants within themselves by means of the oxygen imbibed from the atmosphere and by the carbonaceous matter contained in their sap, they absorb it also from the air, and receive it combined with the water taken in by their spongioles.

That so long as plants remain in the dark the greater part of the carbonic acid is retained, but not fixed in the form of an organic compound until stimulated by the light, when its decomposition is effected; the carbon becomes fixed, and nearly all the oxygen with which it was united, is exhaled into the atmosphere.

Botany, by Prof. Henslow, Cab. Cyc. pp. 175, 184—191, 201, 202. Dr. Ure's Chem. Dict. p. 26. Botany, in Lib. Useful Know. pp. 79—90. Prof. Whewell's Bridg. Treat. pp. 115—117. Daniel's Phil. of Chem. pp. 315—318. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. p. 22, et seq.

125. That Fossil remains of Vegetation are abundant in many geological formations, but especially in the *Coal Measures*; and that the periods of the formations thus abounding in fossilized relicts of vegetation have been grouped into the following four grand epochs, namely:—

1. From the earliest secondary rocks to the uppermost beds of the coal measures; in which upwards of three hundred distinct species have been recognised; the higher tribes of the cryptogamous plants comprising about two-thirds of the whole number.

2. The New Red Sandstone series; affording only a few species of fossil plants.

3. From the lowest beds of the oolitic series to the chalk, inclusive. The few species found in the green sandstone and chalk being chiefly of marine origin; and

4. The beds above the chalk, where dycotyledons begin to prevail, and plants of terrestrial, lacustrine, and marine species entirely different from those of the previous divisions. While the fruits which have been found are referable to existing genera.

Botany, by Prof. Henslow, in Cab. Cyc. pp. 310—314. M. Adol. Brougniart on Fossil Vegetation. Fossil Flora, by MM. Lindley and Hutton. Prin. of Geol. by Mr. Lyell, vol. i. p. 169. Elem. Phil. of Plants, by MM. Decandolle and Sprengel, pp. 276, 277. Manual of Geol. by H. T. de la Beche, pp. 413, 430, et seq. Edin. Jour. Nat. Hist. p. 58. Prof. Buckland's Bridg. Treat. pp. 63, 453, 463, 490—523. Athenæum, No. 985. Ancient World, by Ansted, London, 1847. Phillips's Geology, pp 289, 290.

126. That the result of investigations into Fossil Flora have led eminent geological naturalists to the following conclusions respecting the three great geological periods, namely :—

1. That during the First or Transition epoch, which includes the Coal Measures, there was a predominance of vascular cryptogamia, and a comparative rarity of gymnospermous phanerogames.

2. In the second, an approximation to equality of vascular cryptogamia, and of dicotyledons, composed entirely of gymnosperous phanerogames.

3. In the Tertiary, a predominance of dicotyledons, and paucity of vascular cryptogamic plants. And

4. That during each of these three periods remains of monocotyledonous plants occur, although sparingly.

Prof. Buckland's Bridg. Treat. vol. i. p. 520. Botany, by Prof. Henslow, in Cab. Cyc. pp. 310—314. Lyell's Elemen. of Geol. vol. i. p. 285. Vestiges of Creation, pp. 88—94.

127. That although the fragments of fossil vegetables often possess great beauty, and their tissue may be distinguished under a microscope as completely as in recent species; yet, in general, the remains of ancient plants are not so perfectly preserved as the skeletons of animals or the coverings of mollusca; those parts (the flowers and seeds) upon which the distinction of species and their classification chiefly depend, being very rarely met with and most frequently detached. And that, as

it is principally from these imperfect remains that a comparison between the ancient and present flora can be instituted, such data are by no means adequate to ensure an accurate determination of specific differences, although they afford means of ascertaining truths of high interest.

Under such circumstances it has been agreed to refer the fossil vegetable remains to *genera* whose names are modifications of the recent genera.

Botany, by Prof. Henslow, in Cab. Cyc. pp. 18, 310—314. Edin. Jour. Nat. Hist. p. 23. Phillips's Treat. on Geol. p. 286. Ancient World, by Ansted, p. 80. Vestiges of Creation, pp. 84—88. Fossil Flora, by Lindley and Hutton, vol i. Introduction.

128. That when the principle of life has departed from vegetable substances exposed to the atmosphere, they begin spontaneously to decompose, and their remains, entering into new combinations, form carbonic acid, water, carbonic oxide, and carburetted hydrogen; these modifications continuing until nothing remains but the saline, earthy, and metallic substances originally contained in the vegetable matter. But when the exclusion of the atmosphere and considerable pressure take place, the former circumstance removing the agency of oxygen, and the latter preventing the formation of elastic products, the decomposition does not proceed beyond the accumulation of a carbonaceous residium; from which it is probable have been derived the several varieties of bitumen and coal.

Chemistry, by Hugo Reid, pp. 178—180. Elements of Chem. by Dr. Murray, vol. ii. p. 570. Chemistry, in Cab. Cyc. pp. 33, 286, 342. Botany, by Prof. Henslow, in Cab. Cyc. pp. 7, 14. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. pp. 10—12, et seq.

129. That all material substances may be classed under two divisions: Organised and Unorganised. That the want of organization is the peculiar characteristic of mere inert matter, affords an evidence of the absence of the living principle, and proves that it never has been present in these bodies; while the slightest trace of organization discoverable in any natural

body is a complete proof that life is, or at least once was, present in it.

That organised beings have been sub-divided by universal consent from the earliest ages into ANIMALS and PLANTS; the latter possessing only the simpler powers of vegetation; and that, notwithstanding this classification, it is extremely difficult, and has hitherto baffled the attempts of naturalists to point out the precise limits which separate these two kingdoms of organised existences.

Animal Kingdom, by Cuvier, Edin. Jour. Nat. Hist. pp. 3—5. Botany, by Prof. Henslow, Cab. Cyc. pp. 5—8. Chemistry, by Hugo Reid, pp. 169—172. Mechanics, in Cab. Cyc. p. 30. Architecture of the Heavens, pp. 119, 120. Old Red Sandstone, Miller, Edin. p. 43. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. pp. 3—21, et seq. Dr. Pring on the Laws of Organic Life.

130. That the ANIMAL KINGDOM, from the most perfect of its beings down to the verge of that indistinct line where it comes into contact with the vegetable kingdom, may be comprised within two grand divisions, namely *Vertebrate* and *Invertebrate.* The former being provided with a skull and vertebral column for the protection of the brain and spinal marrow; the latter being destitute of both of these defences.

And that all the beings comprising the *first* great division, when in their perfect state, possess the faculty of voluntary motion; while amongst the invertebrate, although there are some species likewise possessed of the power of locomotion, and others which are endowed with it in a limited degree, there are many which soon become fixed to external substances, and remain, during the whole period of their natural existence, in that condition.

Cuvier's Animal Kingdom, Edin. Jour. Nat. Hist. pp. 13, 18, 19. Hist. of British Animals, by Dr. Fleming, pp. 2, 46, 129. Philos. of Zoology, by idem. Botany, by Prof. Henslow, Cab. Cyc. pp. 5—8, 155—168. Old Red Sandstone, by H. Miller, Edin. 1841. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. p. 4, et seq.

131. That all the INVERTEBRATE *animals* which have not the power of locomotion are natives of the water, whose fluc-

tuations continually bring new objects into contact with their organs of sensation, and by that means supply them with food; and that, although it is difficult to draw a line of distinction between those which are endowed with the faculty of voluntary motion and those which are not, yet such a distinction does actually exist, and is, therefore, capable of being delineated.

Philos. of Zoology, by Dr. Fleming, vol. i. pp. 46, 129. Vestiges of Creation, pp. 247—260. Cuvier's Animal Kingdom, Edin. Jour. Nat. Hist. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. p. 67, et seq.

132. That, with a very few exceptions, the organised existences classed under the denominations of *Zoophyta*, the whole of the *Crinoideæ* and *Blastoideæ*, and among the *Mollusca*, the *Acephala*, *Brachiopoda*, and *Cirrhopoda* must be considered as fixed to one spot during the whole of their perfect existence.

Philos. of Zoology, by Dr. Fleming, vols. i. and ii. Hist. of British Animals, by idem. General Review of Living Beings, Edin. Jour. Nat. Hist. p. 19. Prof. Buckland's Bridg. Treat. vol. i. p. 417. Ancient World, by Ansted, pp. 38, 92—95. Vestiges of Creation, pp. 178, 203.

133. That scarcely any fact in experimental geology is better established than "that the generations of organized bodies, which have successively inhabited the progressive surface of our globe, differ from the present generation in proportion as their exuviæ are farther removed from its actual surface; or, in proportion as the period during which they lived is more remote from the present time."

That there is not a single instance on record amongst geological data to warrant the assumption that any species, once extinct, ever was recreated during a succeeding period of the ancient world; and that *productæ*, *trilobites*, *spirifer*, *orthoceratites*, *ichthyolites*, *ammonites*, *belemnites*, and numerous others of similar category are examples of organised marine bodies having become extinct.

Jameson's Cuvierian Theory, pp. 336—338. Foss. Organic Remains, by M. Alex. Brogniart, in No. xvi. Edin. Phil. Jour. pp. 226—230. Geog. Essay on Superposition, by Humboldt, pp. 48, 57. Nat. Philos. by Sir John Herschel, Cab. Cyc. pp. 282—284. New Walks in an Old

Field, Miller, 1841. Conchol. by Capt. Brown, pp. 58—65. Hist. of British Animals, by Dr. Fleming, pp. xiv. to xviii. Manual of Geol. by H. T. de la Beche, p. 193, et seq. Lyell's Prin. of Geol. vol i. p. 82. vol. ii. p. 133. vol. iii. pp. 59, 253, 254. Prof. Buckland's Brid. Treat· vol. i. pp. 62, 113. Ansted's Ancient World, London, 1847, pp. 54—56. Lyell's Elements of Geol. vol. i. pp. 10, 199—211. Phillips's Geol. pp. 51, 107, 287—289. Vestiges of Creation.

134. That the remains of plantæ, zoophyta, and testacea, are not more profuse and extensive throughout the fossiliferous formations, up to the chalk, than the non-appearance of vestiges of true birds is remarkable; and that no fragment of a quadruped, bird, or reptile has yet been obtained from any of the carboniferous strata in any part of the world.

Lyell's Prin. of Geol. vol. i. p. 171. vol. ii. p. 254. vol. iii. p. 253. Edin. Jour. Nat. Hist. pp. 12, 62. Prof. Buckland's Bridg. Treat. vol. i. pp. 85, 86. Lyell's Elements of Geol. vol. i. p. 355. Phillips's Geology, p. 289. Ancient World, by Ansted, pp. 90, 91, 208. Vestiges of Creation, Table of Classification. Old Red Sandstone, by H. Miller.

135. That when the AUTHOR OF NATURE creates an animal or plant, all the possible circumstances in which its descendants are destined to live are foreseen, and a corresponding organization is conferred upon it to enable the species to perpetuate itself as long as is consistent with His omniscient purposes under all the circumstances to which it will inevitably be exposed.

Lyell's Prin. of Geol. vol. ii. p. 24. Manual of Geol. by H. T. de la Beche. Prof. Whewell's Bridg. Treat. p. 18. Geology, by H. T. de la Beche, pp. 476, 477. New Walks in an Old Field, Miller, 1841. Lyell's Elements of Geology, vol. ii. pp. 435, 436. Phillips's Geology, pp. 285—290. Daniel's Philos. of Chem. pp. 324, 371, 372. Vestiges of Creation, pp. 164, 217—220, 331. Ancient World, by Ansted, pp. 47—51.

136. That all Fish—all that inhabit the waters, except the crustaceous and testaceous animals—are of the same specific gravity as the fluid they live in. That these classes breathe atmospheric air.

That the *molluscuous* and *conchiferous* divisions of the animal kingdom possess no skeleton; their muscles being attached to

the skin, which forms a soft envelope or mantle, whose most important appendix is the shell.

That this latter is secreted by the corium, and increases by coatings in the inner surface, being regulated in form by the body of the animal, with whose existence it is coeval, and cannot be dispensed with; and that the solid matter of the shell consists of carbonate of lime united by a small portion of animal matter resembling coagulated albumen.

Philos. of Zoology, by Dr. Fleming, vol. ii. pp. 401, 402. Cuvier's Animal Kingdom, Edin. Jour. Nat. Hist. pp. 13, 19, 25, 28. Dr. Ure's Chem. Dict. p. 741. Turner's Sacred History, pp. 195—199. Chem. by H. Reid, p. 181. Dr. J. M. Good's Stud. Med. vol. i. pp. 1—38, 494—523. Paper, by Mr. Hatchett, read before the Royal Society, 1800. Daniel's Philos. of Chem. p. 68. Lyell's Elements of Geol. vol. ii. pp. 298, 299.

137. That the evidences afforded by the examination of fossilized zoophyta, mollusca, conchifers, pisces or planta seem alike to indicate the existence of some general law—pervading the primitive fluid wherein they grew and lived—which required that they should encrust themselves with some *solid intermedia* between it and their interior parts; whether these coverings assumed the character of stony particles, testaceous or conchiferous coverings, enamelled plates, or vegetable tubercules, or scales, &c.

Lindley and Hutton's Fossil Flora. New Walks in an Old Field, Miller, Edin. Ancient World, by Ansted, 1847.

138. That Animal Respiration—which consists in the alternate inhalation of a portion of air into the lungs, its transformation there, and subsequent exhalation—occasions, by means of the diffusion principle of gases, and of membraneous endosmose a reinvigorating interchange of gases. The oxygen of the atmosphere abstracting and occupying the place of the carbonic acid of the venous blood, which acid is exhaled in a gaseous form.

That the changes which take place in the elements concerned in the process of respiration have a relation to the elevated temperature of certain *Orders* of animated beings; and that there is, likewise, an immediate connexion between the power

of accelerating voluntary motion and the function of respiration, action of the lungs, and the circulation of the blood.

Murray's Intro. to Chem. vol. ii. pp. 588—591. Dr. J. M. Good's Stud. Med. pp. 494—523. Botany, by Prof. Henslow, Cab. Cyc. p. 187. Chemistry, by Hugo Reid, pp. 57, 58, 61—64. Edin. Jour. Nat. Hist. pp. 24, 25. Dr. Ure's Chem. Dict. p. 704. Chemistry, in Cab. Cyc. pp. 317—322, 329, 332. Heat, in idem, pp. 389—391. Daniel's Philos. of Chem. p. 318. Botany, in Cab. Cyc. pp. 156, 157, 187, 236. Hunt on Light, pp. 199—201. Meteorology, by Dr. Thomson, 1849, pp. 14, 15, 19—21. Physiol. and Anatomy of Man, by Todd and Bowman, 1845, vol. i. pp. 3, 24, et seq.

139. That on the decomposition of animal substances taking place, when moisture and a certain degree of heat is present, putrefaction commences, the elements of the animal matter enter into new combinations, and generally pass off in the gaseous form; ammonia being always disengaged in considerable quantity: phosphuretted, sulphuretted, and carburetted hydrogen, and carbonic acid are likewise separated, and only an inconsiderable portion of earthy matter remains when the process is finished.

Murray's Elements of Chemistry, pp. 655, 676, 677. Dr. Ure's Chem. Dict. pp. 112—117, 695, 696. Chemistry, by Hugo Reid, pp. 180, 181. Chemistry, in Cab. Cyc. pp. 131, 145, 301, 338—340, 342, 343. Daniel's Philos. of Chem. pp. 324, 371, 603, 641—645, 677. Old Red Sandstone, by H. Miller, 1847. Physiol. and Anatomy of Man, by Todd and Bowman, London, 1845, vol. i. pp. 4, 10, 12, et seq.

SECTION II.

THE ANIMAL EXISTENCES OF THE NON-ROTATORY PERIOD.

CHAPTER I.

Preliminary Observations. Subject of Argument in the present Section. Early Conception of a Principle of Limitation involved in the Mosaic Record. "The Moving Thing that hath Life." Definition of the Living Principle. Faint Line of Separation between Vegetable and Animal Vitality. Difference Determined; and also that between Vertebrate and Invertebrate Animals. The former accurately defined and described for the purpose of being eliminated from the Argument. The same method adopted with respect to certain Mollusca, Articulata, and Radiata. Apulmonic Tribes of animals defined generally. Described particularly and very fully, and confirmed by general testimony. Enquiry into the supposed Nature and Habits of the Extinct Races of Inferior Animals.. Evidences of the Extinction of their Races, and of the Successive Creation of others. The Design and Object of their Temporary Existence briefly alluded to, with a view to resume and dwell, in the sequel, upon both of these points.

The quotations from Scripture and the Theorems which are contained in the preceding Section are intended, as we have already stated, to constitute the groundwork of our subsequent reasoning. On the one hand we have given, from the Record of our Faith, the enunciations of the Spirit of Truth relative to a period when there was no created being to bear witness to what was done: "Where wast thou when I laid the foundations of the earth? declare if thou hast understanding!" And, on the other, we have selected, from the writings of the learned and the laborious in research full and complete evidence of that which exists and is appreciable by the senses. The one reveals to us how all things were formed; the other

displays the state in which they are found after having come from the hands of their and our Creator. Assisted by both, we shall endeavour to thread our way through the various branches of argument designed to bring out, in clear and consistent manifestation, the beauteous system of belief which these infallible sources of information and evidence, when taken together, are capable of affording to the mind of man.

But, before we proceed one step further, and while we are yet on the very threshold, we take occasion pointedly to observe that, unless our readers are prepared to receive the announcements of Scripture with as implicit confidence as they would a thrice demonstrated problem, it will avail them little to endeavour to accompany us. We shall be losing sight of each other at almost every turning and winding of the long and intricate path which lies before us: for, we consider it an axiom that there is only one reliable source of information *respecting that which was, and of events which occurred immediately preceding the present order of things;* especially as the preceding did not stand in the relation of natural *cause* to the succeeding, as its *effect;* but indispensably required, in order that it might become so, *intervening acts of Omnipotent will and power.*

Before we commence our discourse we have to make a few observations, as to the method which we propose to adopt in conducting these investigations.

To avoid unnecessary repetition, and to render the work as concise as possible, we shall only give a limited number of authorities in support of such points as it may be deemed necessary to establish; for, where unanimity prevails, further evidence would render the discussion diffuse, and distract the attention: where it does not, a multiplicity of quotations would only increase the difficulty. In making the selection we shall be guided alone by expediency; preferring, in general, those quotations which most clearly and concisely describe the points of the subject to be established, and which afford the best evidences in their favour. In order to convince the understanding it may, in some cases, perhaps, be requisite to bring forward proofs in support of points which might be assumed by common consent. But to compensate for this, we shall endeavour to restrict our own observations to such as may be

necessary to bind one link of the argumentative chain to another: and the whole, we trust, to the minds of our readers.

Some difficulty exists in making a proper selection of the first link to be examined, for the whole is bound together in a circle, the one dependant on the other; no point presents itself in well marked and visible separation so that it might be laid hold of, and enable us, link by link in continuous succession, to unravel the whole. We have, however, after mature reflection, adopted the only plan which bids fair to obviate this difficulty, namely:—to commence at whatever part of the argument appears to be most conducive to its eventual success, and *ad interim, assume as established* whatever other conditions may be necessary for the perfect support of that which first occupies our attention, and afterwards to return upon those which have been thus assumed, and prove them also, on the precise understanding, that should we fail to establish whatever may have been made use of provisionally, then the superstructure will fall to the ground along with that on which it was erected. The point we have chosen to commence with has likewise this recommendation, that it is the most analogous to that where the narrative commences in Scripture: an influential motive of recommendation with us, and we trust also with our readers.

In conformity with this resolution we shall, for the present, consider the EARTH *as a sphere, surrounded by an atmosphereless ocean of different composition from the actual seas, and under the influence of the same forces which at present govern its orbital motion, revolving in darkness round an unillumined sun, but without rotatory motion.* And having done so, we shall endeavour to prove as the first position in our continued and important chain of argument, *that these primitive, dark, and atmosphereless waters were the abode of innumerable races of living apulmonic creatures, independent alike of light or atmospheric air for life or motion; the greater part consisting of descriptions which either were entirely fixed, or moved but imperfectly. That of these there were several successive generations. And that this position is as consistent with the true meaning of Scripture as it is accordant with the results of philosophical investigation and of geological research.*

It may, perhaps, be attended with beneficial effects, were we to retrace the outlines of the path by which we ourselves arrived at the conclusion that, during the protracted period of non-rotation, the primeval waters were the abode of innumerable and successive races of apulmonic creatures, to the exclusion of all, of every description, which depend for locomotion on atmospheric air.

Long after we became convinced that the Earth had revolved for ages in a state of non-rotatory motion around the unillumined sun; had been the abode of certain classes of molluscous animals, whose shelly coverings are everywhere discoverable in its stratified masses; and that all this had been *previous* to the Mosiac week, we were under the most painful perplexity as to how such a state of matters could be made reconcileable with the announcements of Scripture; prepared, as we were, to give up everything which might be at variance with this standard of our faith: believing, at the time, most firmly, as probably all do who have not paid the like attention to these points, while they possess equal confidence in the word of God, that no warrant was to be found in it for the conclusion that *anything could possibly have existed which was not made during the Mosaic week.* The consequent state of mind was, of course, far from enviable. It was positively distressing, for, relying most implicitly on the words of the Divine Record, and ready to sacrifice every thought which might be inimical to it, we could not, on the other hand, close our eyes to the full glare of noon-day light, to the convictions of our senses, which led us to conclude, by what we saw around us, that the remains of those marine animals, found everywhere on the face of the earth, and high above the present level of the ocean, must have been deposited previously to the revolution of the globe around its axis; consequently, before the formation of the light, and while as yet the primeval ocean surrounded its entire spherical surface.

Assailed thus powerfully and equally by contending opinions, both of which appeared to carry the evidence of conviction, while they seemed to resist a cordial reconciliation with each other, we were completely at a loss which way to turn. During one of these fierce and protracted contests, when every argument

had been tried, and every *instancia cruces* had been brought forward in vain; when, almost worn out with the intensity and tenacity of the jarring principles within, and about to seek rest by abandoning the philosophical evidences altogether and adhering implicitly to the words of inspiration, it occurred to us, as a last resource, that, perhaps, the expressions therein made use of might admit of such an interpretation as would pave the way to a thorough reconciliation between the two; and thus save us from making such a sacrifice as that which we felt inclined to make to secure, as we thus thought, the tranquil enjoyment of our scriptural tenets, but which, in fact, would have had the effect of greatly lessening that enjoyment.

Fortunately, the Bible, which at that juncture lay most convenient for immediate consultation, was the celebrated Spanish one by the Very Rev. F. Scio de San Miguel; on taking it up and referring to the passage in question, we found the following explanation, which, unphilosophical as it may appear, supplied the first step towards unravelling the difficulty:—

"God also said, Let the waters produce animated reptiles* (more literally, "reptiles of living minds"), and birds which fly above the earth under the firmament of heaven. Gen. i. 20.

This, although a very unscientific explanation of the passage commented on, nevertheless was made the means of awakening us to a conception of the truth, faint, it must be confessed, at

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* That is, animated *reptiles*, or those which have life. Fishes are so called, because what is principally recognized in them is the head and tail; and as they are deficient of limbs (literally of both *legs and arms*), they appear to move as if dragging themselves through the water. And thus the word "*reptile*" is alike applicable to fishes which swim and to animals which drag themselves along the ground.*

* "Dixo tambien Dios; produzcan las aquas reptil,* de anima viviente, yave que vuele sobre latierra debaxo del firmamento del cielo."

* "Esto es, Reptiles animados, o que tengen vida, asi llaman à los peces, porque lo que principalmente se reconoce en ellos, es la cabeza y-la cola; y-como carecen de pies y de brazos, parece que van arrastrando por las aquas. Y, asi el *Reptil* se aplica tanto al pez que nada, como al animal que va rastrando por la tierra."—*Biblia por el M. R. P. Phelipe Scio de San Miguel. Tomo* 1, *pagina* 8.

first, but sufficient, notwithstanding, to mark where the point of junction lay between two masses of undeniable evidences.

On turning from the Spanish theologian's explanation to that given in our own version, we were struck with the apparent analogy, and at the same time with the seeming care which had been employed in framing that part of Scripture. The words "*moving creature that hath life*" kept possession of our mind with the tenacity of that which is destined to take root and flourish—with the glow of vitality itself.

But, as already indicated, the imperfect explanation afforded by the Spanish translation, led only to the first step of our enquiry into the real facts of the case. It directed our attention, with undeviating steadiness, to the *principle*, which induced the peculiar wording of this portion of Scripture—and that *principle* was, *that a line of division had been intended to be clearly and emphatically drawn between certain races of marine creatures which were, by the Command itself to start into being, and certain other tribes of the same grand division of animal life, which had existed previously.*

Convinced of this, our next step was to ascertain, if practicable, the direction of this line of demarcation, or the point where it commenced on the scale of creation. After much thought it occurred to us, that if the *revealed* were perfectly known and applied to the *whole existing races* of animated creatures, all those which are over, as it were, must have been willed previously into being. For the *revealed might* be known, but the *un*revealed could only thus be inferred, and afterwards be confirmed by a comparison with fossil exuviæ. Subsequent enquiries into the more precise meaning of the words used at the commencement respectively of the 20th and 21st verses, convinced us that their nearest synonimes are "And God said. Let the waters swarm forth living swarming creatures, and let them produce abundantly, ... and fill the waters in the seas," &c., which description, when applied to the collective tribes of creatures known to inhabit the waters, seemed to exclude a vast multitude. It could not, we imagined, comprehend those which are fixed to other bodies; those which creep along the bottom of the ocean; nor any which do not possess the faculty of moving freely and rapidly. In short, all that

are independent of atmospheric air to sustain them in life and to enable them to move. Every creature so constituted, whatever may be their form or constitution, we concluded, was known by the inspired historian to have existed previously, and, therefore, *had been carefully and deliberately excluded from the Creative Command on the fifth day of the Mosaic week.*

From the moment we came to this conclusion we never doubted but that the principle which led us to it would afford the long-wished-for explanation of this hitherto inscrutible arcana; and our attention, thus freed from doubt, became wholly directed to ascertain whether the discoveries of philosophy would bear out these robust, but incipient conceptions. We proceeded by the way of differential reasoning, if we may be permitted so to express ourselves, and the more we read, studied, examined, and compared, the more firmly we became convinced that we were on the right path. That those marine animals *which do not* depend for motion on atmospheric air were capable of existing previously to the formation of the light; that *they* only could fulfil the purposes which were then to be wrought out; and, knowing this, the inspired historian meant, as we have said, carefully and deliberately to exclude them from the narration given of the operations of the *first part of the fifth day*. The result of these researches, in further confirmation of our assumption, we now proceed to lay before our readers.

We shall commence, by enquiring, in accordance with the differential method, whether naturalists acknowledge a class or division of beings which correspond with the definition we have just given; observing, in general, that whatever creatures did exist *before* the formation of the atmosphere *must have been inhabitants of the water.*

Let us first, then, examine the evidences in favour of what it is to be possessed of life, or of the *living principle*. By the first part of the *hundred and twenty-ninth* Theorem it will be seen "*That the want of organization is the peculiar characteristic of mere inert matter; affords an evidence of the absence of the living principle; and proves that it never has been present in these bodies during their formation or increase,*

while the slightest trace of organization discoverable in any natural body is a complete proof that life is, or at least once was, present in it. These are the words of Professor Henslow, in his Treatise on Botany in the Cabinet Cyclopædia. We shall see, presently, how fully his proposition is borne out by the opinions of other writers.

"Life," says Baron Cuvier, "being the most important of all the properties of created existence, stands first in the scale of characters. It has always been considered the most general principle of division; and, by universal consent, natural objects have been arranged into two immense divisions, ORGANIC beings (comprising animals and plants); and INORGANIC beings (comprising minerals)."

And again,

"In conclusion, we shall repeat, that all living bodies are endowed with the functions of absorption (by which they draw in foreign substances); of assimilation (by which they convert them into organized matter); of exhalation (by which they surrender their superfluous materials): of development (by which their parts increase in size and density); and of generation (by which they continue the form of their species). Birth and death are universal limits to their existence: the essential character of their structure consists in a cellular tissue or network capable of contractibility; containing in its meshes fluids or gases, ever in motion; and the bases of their chemical composition are substances easily convertible into liquids or gases; or into proximate principles, having great affinity for each other. Fixed forms, transmitted by generation, distinguish their species, determine the arrangement of the secondary functions assigned to each, and point out the part they are destined to perform on the great stage of the universe. These organised forms can neither produce themselves nor change their characters. Life is never found separated from organization; and, whenever the vital spark bursts into a flame, its progress is attended by a beautifully organized body."*

"Notwithstanding this vast and exuberant presence of organic existence," says Professor Ansted, "it is yet true that we cannot even imagine the nature of the broad line of demarcation which seems, as

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* Edinburgh Philos. Journal.

it were, to form an impassable gulf between that which we call living, and that which is only dead matter.

"Life is no less a mystery to us now, than it was when man first speculated on its nature. We know not what it is, why it is, or how it is; we know, only, that it exists and is everywhere present. The development of one form of life from another may, therefore, well remain undetermined, since we cannot even guess at the nature of that first change which produces organization, and which thus acts upon organic nature."*

"It is very difficult," say Messrs. Todd and Bowman in their admirable Physiological Treatise, "to define a precise boundary between the vegetable and animal kingdoms. The lowest animals exhibit so much of the plant nature that naturalists are as yet undecided as to the true location of some species. The common sponge, for instance, is claimed for each kingdom.

But "*living* objects, generally, are strongly contrasted with the inanimate bodies (which have never lived). . . . . . At the same time, there are many points of resemblance between them; and as both owe their origin to the same creative mandate, and are reducible to the same elementary constituents, so they are subject, in a great degree, to the same physical laws, and are to be investigated according to the same principles of physiological enquiry.

"We propose, in the first place, to compare living, or organized bodies, with inanimate, mineral, or unorganized bodies, and to explain what is meant by the term LIFE. . . . . .

"1. Every living being is organized—that is, composed of different parts or *organs*, each of which has its definite structure, by which it differs from other parts, and is capable of fulfilling a certain end. . . . . .

"The various bodies that compose the mineral kingdom do not exhibit the same distinctness and variety of structure in their component parts, nor is there any adaptation of their parts to separate functions; they are, therefore, called *unorganized* or *inorganic*, and chemical analysis resolves them into those simple elements which admit of no further sub-division.

"Organized bodies are found in two states or conditions. The one, that of *life*, is a state of action, or of capacity for action. The other, that of *death*, is one in which all vital action has ceased, and

* Ancient World, 1847, p. 394.

to which the disintegration of the organized body succeeds as a natural consequence. . . . . .

"The term LIFE, then, may be regarded as denoting an ultimate fact in science, which may be thus expressed: that certain compounds of matter—which, as being artfully arranged in a particular form for a special end, and associated together by a certain mechanism, are called *organized*—do, by their co-operation with physical and chemical forces, manifest a train of phenomena, which are of the same, or of an analogous kind, for all organized beings; that is to say, they manifest the phenomena of LIFE. . . . . . Life is transmitted from one living being to another; the life of the present generation of animals and plants has its source in that of a previous generation.

"And if we trace a race upwards through generations innumerable to that which first flourished on the earth, we find the true source of vital creation to be in Him 'in whom we live, and move, and have our being.'"*

Having ascertained from these authorities what the characteristics are which constitute an organized or living being, it becomes necessary to delineate, as clearly as possible, the distinguishing properties of the animal from the vegetable kingdom.

By the *one hundred and twenty-ninth* Theorem it will be perceived that the lower boundaries of these two divisions of organized existences are so contiguous, indeed so frequently blended, that it "*has hitherto baffled the attempts of naturalists to point out the precise limits which separate them;*" for, to this day, there are some objects which it is very doubtful under which class they ought to be arranged. Observe what Professor Henslow says in continuation of these words which we have selected for the Theorem:—

"Among the higher tribes of organized bodies, indeed, there is no difficulty in pointing out numerous lines of demarcation between the two kingdoms; but, as we descend in the scale of each, we find an increasing similarity in external characters, and a closer approximation between the analogies existing in many of those functions

* Physiology and Anatomy of Man. London, 1845, pp. 21, 22, 3, 14, 15.

which mark the presence of the living principle, both in the animal and in the vegetable kingdoms.

"Indeed, so very closely do the limits of these two great kingdoms approximate, that it is even now a matter of doubt whether the *Conferva Comoides*, which has hitherto been considered as an aquatic plant, does not more properly pertain to the lower confines of the animal kingdom. An opinion which has been adduced from observation by Mons. Gaillon, and confirmed by the later investigations of MM. Desmazieres and Chauvin."

We have just been informed that the *common sponge* is in the same predicament.

But difficult as it may be to effect this separation, an attempt has been made to accomplish it; and with relation to the *hundred and thirtieth* Theorem it may be observed, that the following seem to be the conditions which essentially constitute the animal state of organic existence; those which do not possess these qualifications taking their rank in the vegetable kingdom:—"1. *Animals are possessed, in some form or other, of an alimentary cavity, or intestinal canal.* 2. *They are endowed with a circulating system.* 3. *That, besides the three elements, oxygen, hydrogen, and carbon, which both plants and animals contain, the latter have a fourth, namely, azote or nitrogen, which enters more largely into their composition.* 4. *They possess the power of respiration. And, lastly. That, perhaps, the super-addition of sensibility to the common living principle, is requisite to complete the characteristic property of animals.*"

Baron Cuvier, in the Introduction to his "Animal Kingdom," confirms these positions by stating

"The power of voluntary motion in animals necessarily requires corresponding adaptations, even in those organs simply negative. Animals cannot, like plants, derive nourishment from the earth by roots; and hence, they must contain within themselves a supply of aliment, and carry the reservoir with them. From this circumstance is derived the first trait in the character of animals. They must possess an intestinal canal, from which the nutritive fluid may penetrate by a species of internal roots, through pores and vessels into all parts of the body. . . . . .

"The complicated functions of animals require organized sys-

tems, which would be superfluous in vegetables; such as the muscular system for motion, and the nerves for sensation. It was also necessary that the fluids should be more numerous and varied in animals, and possessed of a more complicated chemical composition than in plants, in order to facilitate the action of these two systematic arrangements. Therefore, another essential element was introduced into the composition of animals, of which plants, excepting some few tribes, are generally deprived; and while plants usually contain only three elements, oxygen, hydrogen, and carbon, animals add to these a fourth, namely, azote or nitrogen. This difference in chemical composition forms the third trait in the character of animals. . . . .

"Respiration forms the fourth characteristic of animals, and is the most distinguishing function of the animal frame, namely, that which forms its essential difference from all other beings, and, in a manner, constitutes it an animal. So important is its influence over the whole body that we shall presently be able to show that animals perform the functions of their nature with greater or less perfection, according as their respiration is more or less perfect."

In addition to these luminous definitions, it is only requisite to give that which has been adduced by Professor Henslow, as the remaining condition of animal existence:—

"Perhaps," he says, "until the contrary shall be distinctly proved, we may consider the superaddition of 'sensibility' to the living principle as the characteristic property of animals; a quality by which the individual is rendered conscious of its existence or of its wants, and by which it is induced to seek to satisfy those wants by some act of volition. It has been supposed—and both analogy and experiment appear most fully to confirm the supposition—that a sense of pain is very nearly, if not entirely, absent in the inferior tribes of animals. Even in the higher tribes, certain parts of the body are incapable of receiving pain; and there seems to be no absurdity in considering that an animal may be endowed with just so much sensibility as may be sufficient to prompt it to select its food, though, at the same time, its body may be so organised as to be incapable of transmitting painful sensations."

We can now distinguish an organised being from mere inert matter which constitutes the mineral kingdom; and in continuation, have acquired such a knowledge of the characteristic peculiarities of an animal, as to distinguish it from a plant.

In short, we now know *what a* "*creature*" is which *hath* "*animal life.*" In continuation, we shall enquire whether any of these are so circumstanced as to be independent of light and atmospheric air; commencing with such as, being immovable during the whole period of their existence, are most decidedly indifferent to both these influences. In effecting this, we wish it to be clearly understood, that the *immovability* to which we allude is that which is akin to the *immovability of a tree*; whose static condition cannot be questioned, although its seeds may be wafted by the winds, or borne by the waters to a distance, there to take root, and, in turn, from thence to spread further and further over the face of the earth. In like manner, we assert that any mollusc or zoophite which ultimately adheres to a rock, and thereafter continues fixed, is *an immovable creature,* although it should be proved that its spawn separates itself from the parent mollusc; and, either by the currents of of the water, or even by rotiferous motion, succeeds in reaching a convenient distance from the original bed; there, like the race to which it belongs, to become a permanent fixture, and to send forth, in turn, animals of its own kind, ephemerally endowed with the faculty of locomotion. We maintain that, in respect of fixity, these two extensive groups of created existences are precisely upon a par, and that the immovability of the *ostrea* or the *patella* can no more be questioned than that of a shrub or a tree. While by "restricted motion" we mean such as, during the whole course of their existence, creep upon, or burrow in the bottom of the ocean, and are incapable of swimming freely. In short, all those whose motion is not the effect of aerated blood, even although they should, by means of the surrounding element, be capable of restricted movements of mechanical origin.

In conducting our inquiries into this matter, we shall adopt the method of eliminating from the extremes, those animals whose nature and conformation leave no doubt as to their possessing the power of locomotion, close in by degrees upon the more questionable descriptions, situated upon the very line of demarcation, and, at last, arrive at such as are positively deprived of the faculty in question.

By the *hundred and thirtieth* Theorem it is asserted "*That*

the animal kingdom, from the most perfect of its beings down to the verge of that indistinct line where it comes into contact with the vegetable kingdom, may be comprised within two grand divisions, namely, VERTEBRATE *and* INVERTEBRATE. *The former being provided with a skull and vertebral column for the protection of the brain and spinal marrow. The latter being destitute of both of these defences."*

This is so rudimentary a truth in natural history, and so well known to all who have paid the slightest attention to its study, since Lamark adopted this method of classification upon *positive* and *negative* principles, that it is scarcely necessary to delay our investigations to prove it. We shall, therefore, proceed to give the description of animals which constitute its *positive branch*—the VERTEBRATE :—

"VERTEBRATED ANIMALS," says Baron Cuvier, "the first of whose forms is that of man, and of the animals most resembling him, have the brain and the principal trunk of the nervous system enveloped in a bony covering, composed of the cranium (or skull), and the vertebræ (or bones of the neck, back, and loins). To the sides of this medial column are attached the ribs, and the bones of the limbs, forming collectively the framework of the body. The muscles, in general, enclose the bones which they set in motion, and the viscera are contained within the head and trunk. They are all supplied with red blood, a muscular heart, a mouth with two jaws, one being placed either above or before the other, distinct organs of sight, hearing, smell, and taste, in the cavities of the face, and never more than four limbs. The sexes are always separate, and the general distribution of the medullary masses with the principal branches of the nervous system, are nearly the same in all. Upon examining attentively each of the parts of this extensive division of animals, we shall always discover some analogy among them, even in species apparently the most removed from each other; and the leading features of one uniform plan may be traced from man to the lowest of the fishes."*

We need seek no further evidence on this point: whoever reflects for a moment must be convinced that the very possession of a skull and vertebral column, with their contents and

* In Appendix A there will be found a Synoptical Table of the entire animal kingdom, according to Baron Cuvier, to which please refer.

accompaniments, the brain and spinal nervous cord, is sufficient proof that their possessors *live and move themselves.* But that we may know what animals belong to this class, we subjoin the list given of them by the same illustrious anatomist.

THE ANIMAL KINGDOM.

DIVISION I.—VERTEBRATA.—Subdivided into four Classes.

1. MAMMALIA.—Man and beasts with warm blood; heart with two ventricles; females suckling their young with milk; viviparous, excepting the Montremata, which are either viviparous or ovoviparous.
2. AVES.—Birds, with warm blood; heart with two ventricles; no mammæ; oviparous; body covered with feathers; and organised for flight.
3. REPTILIA.—Reptiles, with cold blood; heart with one ventricle; having lungs, or sometimes only gills or branchiæ; oviparous or ovoviparous, generally amphibious.
4. PISCES.—Fishes, with cold blood; heart with one ventricle; no lungs, but breathing by branchiæ; generally oviparous; *body organized for swimming.*

We at once, and without hesitation, eliminate from our future argument, the whole of the multitudinous tribes of animals which comprise these four classes, MAMMALIA, AVES, REPTILIA, and PISCES. They were all called into existence on the fifth and sixth days of the Mosaic week. Not one of them existed previously.*

In the other three divisions, MOLLUSCA, ARTICULATA, and RADIATA, *some* of the classes are as decidedly on the same side of the line of demarcation; and we proceed to single them out, that they also may be set apart from our future argument.

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* In making this assertion we are well aware of the difficulty which may arise respecting the *fourth* great class, PISCES; but, besides having reference to *true fishes* only, or such as are possessed of perfect organs of locomotion, we are prepared to explain, in the sequel, the peculiar difficulties which beset this part of our discourse. Meanwhile, we shall proceed on the assumption that no *true fishes* which aeriated their blood by gills or branchiæ did exist during the preparatory stage of the world, or *before* the Mosaic week.—AUTHOR.

Division II.—Mollusca.—Subdivided into six Classes.

1. Cephalopoda.—Cuttle fishes, having the mantle furnished with a shell, and united under the body, forming a muscular sac; head connected with the mouth of the sac, and crowned with long and strong fleshy limbs for swimming with and seizing their prey; two large eyes; and two gills placed in a sac; sexes separate.
2. Pteropoda.—Marine animals without feet; with two fins, placed one on each side of the mouth; head distinct; hermophrodites.

Division III.—Articulata.—Subdivided into four Classes.

2. Crustacea.—Marine animals, with a crustaceous envelope; having articulated limbs attached to the sides of the body; blood white; always with articulated antennæ or feelers in front of the head, and generally four in number; distinct organs of circulation; respiring through branchiæ.
3. Arachnides.—Spiders, with the head and breast united in a single piece; and with the principal viscera situated in a distinct abdomen behind the thorax; without attennæ; oviparous.
4. Insecta.—Insects, divided into three distinct parts, the head, thorax, and abdomen; always with two antennæ, and six feet.

Division IV.—Radiata.—Subdivided into five Classes.

2. Entozoa.—Intestinal worms, with no distinct organs of circulation or respiration; body generally elongated and organs arranged longitudinally, without head, eyes, or feet.
3. Acalephæ.—Medusa, or sea nettles, without organs for circulation or respiration; with only one entrance to the stomach.
5. Infusoria.—Animalcules, or minute microscopic animals, found in fluids, or vegetable infusions. As their internal structure is but little known, from their extreme smallness, this class will probably be found, hereafter, to contain animals which ought to be placed in some of the higher divisions.

These eight classes, Cephalopoda, Pteropoda, Crustacea, Arachnides, Insecta, Entozoa, Acalephæ, and Infusoria, may also, we think, without any fear of regret hereafter, be

eliminated at once as pertaining to "*the moving creature that hath life*;" and, for the same reason, will not again require to be referred to, or brought forward.

It is extremely difficult, when treating of a description of animals whose habits are so little known to us as those of the inferior tribes of MOLLUSCS, RADIATA, and ZOOPHYTA, to be able to draw the line of separation between those endowed with the faculty of locomotion and those which are deprived of it: a difficulty by no means lessened by having to infer the habits of extinct races by comparison with living congenors. Fortunately, however, our limitations are sufficiently plain; and render us independent of very minute lines of distinction. If a creature was dependent for life and motion on atmospheric air it is on the one side: if it was not, it is on the other. Nevertheless, to enumerate all that are on either side of that great boundary line would lead us into details too diffuse and inconsistent with the design of this work. We shall, therefore, adduce the distinguishing characteristics of entire groups, which sufficiently evidence the immovability of numerous included tribes of submerged aquatic animals. The following, which is Baron Cuvier's classification, is the most appropriate for our purpose:—

DIVISION II.—MOLLUSCA.

4. ACEPHALA.—Aquatic animals, generally with a bivale or multivalve shell; without an apparent head or limbs; mouth concealed between the folds or in the bottom of the mantle; hermophrodites; branchiæ external; *incapable of locomotion.*
5. BRACHIOPODA.—Marine animals, without a head; having two fleshy arms, furnished with numerous filaments; bivalve shells, *incapable of locomotion.*
6. CIRRHOPODA.—Barnacles, enclosed in a multivalve shell, with numerous articulated limbs or cirrhi, disposed in pairs, *incapable of locomotion.* General structure approaching to articulated animals.

DIVISION IV.—RADIATA.

4. POLYPI.—Small gelatinous animals, with only one entrance to

the stomach surrounded with tentacula; generally adhering together and forming compound animals.

We shall probably have occasion, before we quit this branch of our general subject, to exhibit some further particulars respecting the animals comprising these classes, and have to refer to them repeatedly during the whole treatise; but in the meantime it is considered to be deducible from the direct, though unconscious testimony of a man, whose evidence it will be somewhat difficult to set aside, that the three first—ACEPHALA, BRACHIOPODA, and CIRRHOPODA—belong to the great division of "*the immovable* creature that hath life;" are independent of atmospheric air, and as such must rank accordingly in all deductions which may, hereafter, be legitimately drawn from that fact. It will also, we think, be readily conceded that the *Polypi*—with some slight exceptions—which include the Zoophyta, may be added to those which find themselves also on the *immovable* side of the line of demarcation.

Of the Third Division, ARTICULATA, we have already allocated the *Second, Third,* and *Fourth* classes to the great group of animals fully possessing the *faculty of locomotion*; therefore, we have only now to account for the several *Orders* comprising the

1. CLASS.—ANNÆLIDES. Of this class we consider the several *orders* are composed of molluscs; having the power freely to change their position at will, being generally, without shelly coverings, and consequently irrelevant to our present argument, except the

1. ORDER.—SEDENTARIÆ, consisting of the following four tribes and fourteen genera, all of which are protected by a testaceous tube which they never leave during life; and have the branchiæ at one extremity of the body, namely:—

TRIBE I. SEPULUCEÆ.—*Genus* 1. Megilus; 2. Galeolaria; 3. Vermilia; 4. Serpula; 5. Spirorbis.

" II. AMPHIHITÆA.—*Genus* 6. Amphihita; 7. Terebella; 8. Sybellaria; 9. Pectinaria.

TRIBE III. MALDONIÆ.—*Genus* 10. Dentalium; 11. Brochus; 12. Cornuoide; 13. Clymene.
" IV. DORSALIÆ.—*Genus* 14. Siliquaria.*

To these several tribes and genera we lay our formal claim, as pertaining to the grand *Scriptural* division of animals *which live, but move not voluntarily and freely from place to place.*

This brings us to the two remaining classes of the Cuvierian arrangement of the Animal Kingdom, which our adherence to the great leading distinctives already so often alluded to has constrained us to leave to the last, in consequence of there being found amongst them a great proportion of beings relative to which it is difficult to determine on which side of the line of demarcation they should be placed. Our own opinion—the result of much attention—leads us to conclude that, with the execption of the *Pulmonata,* the greater proportion will eventually be found to belong to that great group of *living creatures which do not move by means of aeriated blood.*

The two classes alluded to are

II. *Division (Cuvierian)* MOLLUSCA.
III. *Class.—Gasteropoda.*
IV. *Division.*—RADIATA.
I. *Class.—Echinodermata.*

The general classification we have thus given seems to embrace the animals which, with great deference, we consider distinctively characterized as those which may not be considered "*the moving creature that hath life,*" and known as such to the inspired writer of Genesis to have existed in the primeval ocean, unendowed with the faculty, in its plenary sense, of self movement; in a condition somewhat analogous to that of the globe they inhabited, which was without rotatory motion, uncheered by the light of the sun, and as yet without an atmosphere.

But in order that we may be benefitted, in a greater degree, by our present labours when we come to apply the results to future reasoning, and endeavour to identify those tribes which we consider to have belonged to the non-rotatory period with

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* Conchologist's Text Book, pp. 148—159.

the lists of fossil exuviæ brought to light by geologists, we shall go somewhat more into detail with respect to those which we consider to have belonged to the *primitive* division. The following are the essential outlines of the particulars given by Dr. Fleming in his Treatise on British Animals of the Gasteropoda, exclusive of the *Pulmonifera*,* namely—

Sect. II. GASTEROPODA.—*Organs of progressive motion fitted for creeping.*

Division II. Branchifera.—*Respiring in water.*

Tribe I. Nudibranchia. *Marine.*

Genus—Doris, Policera, Tergipes, Tritonia, Montagna, Eolida, Valvata, Patella, Chiton.

Tectibranchia.—Applysia, Pluerobranchia, Bulba.

Tribe II. Pectinabranchia.

Division—Cryptobranchia.

Holostomata.

Turbonidæ.—* *Marine.*—Turbo, Phasianella, Turritella, Cingula, Odostomia, Monodonta, Scalaria, Cyclostrema, Delphinula, Cirus, Skenea, Euomphalus.

** *Fluviatile.*—Paludina, Ampullaria, Melania.

Neritadæ.—* *Marine.*—Nerita, Natica.

** *Fluviatile.*—Neritina.

Trochusidæ.—Trochus, Solarium, Janthina, Velutina.

Division I.—Solenostomata.

A. Conusidæ.—Conus, Terebellum, Seraphs.
B. Cypræada.—Cypræa (Cypreovula).
C. Ovuladæ.—(Ovula), Volva, Calpurna.
D. Volutadæ.—Voluta, Volvaria, Mitra, Cancellaria.
E. Marginelladæ.—Marginella, Columbella.
F. Olivadæ.—Oliva, Ancillaria.
G. Tornatelladæ.—Tornatella, Acteon.
H. Bellerephon.—Bellerephon.

Division II.—*Shell turrited, whorls sub-conical, slightly embracing.*

Buccinidæ.—Cassis, Morio, Nasa, Ricinula, Purpura, Monoceras, (Concholepas), Harpa, Dolium, Buccinum, Eburnea.

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* We have almost exclusively restricted these enumerations to the names of *Genera*, to admit of comparison with those discovered fossil in the strata.

PECTINABRANCHIA.

MURICIDEÆ.—Turbinella, Fasciolaria, Terebra, Pyrula, Fusus, Pleurotoma, Ranella, Murex, Typhis, Triton.

CERITHIADÆ.—* *Marine.*—Cerithium, Strutheolaria.
** *Fluviatile.*—Potamedum, Melanopsis (Pirena).

STOMBUSIDÆ.—(Stombus), (Pterocera), Rostellaria.

SCRUTIBRANCHIA.—*I. Shell ear-shaped.*—Haliotis (Padola), (Stomatia).
II. Shell oblong or conical.—Crepidulidæ.
* *Marine.*—Plate of the cavity spirally decarrent. Calyptrœa, Infundibulum, Crepidula, Pileolus.
** *Fluviatile.*—Navicella.

CAPULIDÆ—Capulus (Carinaria).

FISSURELLADÆ.—Fisurella, Emarginula, Scissurella.*

The following are the particulars given by the same indefatigable naturalist, of the Mollusca *Acephala*, and *Branchiopoda*; which we transcribe in continuation of the division of the *immovable* "creature that hath life."

MOLLUSCA. ACEPHALA.

ORDER II.

MOLLUSCA. ACEPHALA.—Destitute of a distinct head or neck; no rudiments of organs of hearing and sight: organs of the two sexes incorporated in the same individual.

SECTION I.

CONCHIFERA.—Covering testaceous.

DIVISION I.

BRANCHIOPODA.—All the species are marine and permantly attached.

PEDUNCULATA.—Lingula, Tesebratula, Spirifer, Magas.

SESSELIA.—Discina, Criopus, Pentamerus, Productus.

DIVISION II.—BIVALVIA.

ASIPHONIDA.—*I. Valves closed by one abductor muscle.*
A. Shell free, or adhering to other bodies by byssus.

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* British Animals, pp. 281—366.

PECTONIDÆ.—Shell compact.—Pecten, Lima, Plagiostoma, Pedum. Shell foliated.—Gryphæa, Vulsella, Placuna.

PERNADÆ.—Perna, Gervillea, Crenatula, Inoceramus, Malleas.

AA. Shell fixed or cemented to other bodies.

OSTREADÆ.—Ostrea, Hinnites, Dianchora, Anomia.

SPONDYLIDÆ.—Spondylus, Plicatula.

II. Valves closed by two abductor muscles.

A. *Hinge with teeth.*

ARCADÆ.—Arca, Cucullea, Pectunculus, Nucula.

TRIGONIADÆ.—Trigonia, Castalia, Avicula.

AA. *Hinge without teeth.*—Meleagrina, Pinna.

SIPHONIDÆ.—Cloak more or less closed, forming syphons.

I. One syphon only.

A. *Shell transverse.*

MYTILIDÆ.—Mytilus, Modiolus, Lithodomus.

UNIONIDÆ.—*Hinge simple.*—Anodon (Iridina).

Hinge with teeth.—Unio, Alismadon.

AA. *Shell with prominent beaks.*

CARDITADÆ.—Cardita, Venericardia, Crassatella.

II. Cloak closed anteally and retrally, with three openings towards the middle of the ventral margin. TRIDACNADÆ.

III. Cloak open anteally.

A. *Shell ear-shaped.* CHAMADÆ. Chama, Diceras, Etheria. CARDIADÆ. Isocardia, Hippopodium, Cardium, Pholadomya, Cypricardia.

AA. *Shape various.* CORBULADÆ. Corbula, *Equivalve.* MACTRADÆ. Mactra, Goodallia, Lepton, Kellia, Loripes, Ervillia, Amphidesma.

Ligament external. DONACIDÆ. Donax, Capsa, Tellina.

No lateral teeth. Psammobia, Astarte, Lucina, Myrtea.

Three teeth at least. CONQUES of Lamark.

* *Marine.* VENERIDAÆ. Cyprini, Cytherea, Venus, Venerupis.

** *Fluviatile.* CYCLADÆ. Cyclas, Cyrena, Galateola.

IV. Cloak closed ventrally, &c.

A. *Lodged at the extremity of a calcareous tube, with which it is more or less intimately connected.* TE-

REDINIDÆ. Teredo, Xylophaga, Fistulana, Clavagella.

AA. *Destitute of a secreted calcareous tube.*

PHOLADÆ.—Pholas, Gastrochæna.

SOLANIDÆ.—No accessory valves.—Solen, Sanguinolaria, Hiatella, Panopæa, Glycemeris.

MYADÆ.—Ligament internal.—Mya, Lutraria, Sphenia, Pandeora, Galeoma.

MOLLUSCA TUNICATA. DICHITONIDA. All the British Dichitonida are fixed.

A. *Body simple.*

a. Apertures furnished with four rays. Pandocia.

a a. Apertures with indistinct rays, or more than four.

b. Body pedunculated.—Clavellina.

b b. Body sessile.—Pirena, Ciona, Phallusia.

AA. *Body compound.*

Polyzona, Sydneum, Alpidium, Botryllus.*

For the necessary particulars of the Class *Cirripeda,* we are indebted to another work on Conchology; which, among other distinguishing characteristics, declares that all the Molluscs of this division "*are incapable of locomotion.*" †

CLASS CIRRIPEDA.—Divided by Lamark into two orders.

ORDER I.

PEDUNCULATE.—The body supported by a tubular moveable peduncle, the base of which is attached to extraneous substances in the ocean. It consists of the following genera:—

Genus.—1. Otion. 2. Cineras. 3. Pollicipes. 4. Sarpellum. 5. Anatifa.

ORDER II.

SESSILIA.—Body without a peduncle, and inclosed in a multivalve shell; seated immediately on marine bodies or rocks. It is composed of,

Genus.—1. Prygoma. 2. Creusia. 3. Acasta. 4. Adna. 5. Balanus. 6. Coronula. 7. Tubicinella.‡

* History of British Animals, pp. 367—471.

† Captain Brown on Conchology.

‡ Conchologist's Text Book, p. 148.

And lastly, again we turn to Dr. Fleming for such a description of the *Echinodermata* and *Polypi*, as the British shores afford; which, although necessarily restricted in the latter division, will yet be sufficient to convey a distinct general idea of the existences which come under these denominations.

ECHINODERMATA.

Section I. Order I.—Free.

A. Echinidæ.—Covering of immovable testaceous plates, without projecting arms.

I. Anocysti.—Vent in the dorsal surface.—Cidaris, Echinus, Clypeus (Cassidula, Nucleolitis).

II. Pleurocysti.—Echinarachnius, Spatangus.

III. Catocysti.—Echinocyamus (Echinanthus, Echinodiscus), Conulus (Echinoneus), Echinocorys.

AA. *Covering crustaceous and moveable.*

Fistulidæ.—Holothuria, Cuvieria, Mulleria.

Asteriadæ.—Asterias, Ophiura, Astrophyton, Comatula, Marsupites.

Section II.—*Destitute of suckers for locomotion.*

Sipunculus, Priapulus.

Order II.—Fixed.

Crinoidæ.—Apiocrinites, Pentacrinus, Encrinites.

II. Plates of the body articulating imperfectly.
Poteriocrinites.

III. Plates of the body adhering by sutures.
Cyathocrinites, Caryocrinites, Actinocrinites, Rhodocrinites, Platycrinites.

IV. Plates of the body anchylosing.
Eugeniacrinites.

Blastoidæ.—Margin of the oral disc destitute of arms.
Pentremites.

"The fossil remains of Crinoideasis," says Professor Buckland, "have long been known by the name of Stone Lilies or Encrimites, and have lately been classed under a separate order by the name of Crinoidea.

This order comprehends many genera and numerous species, and is arranged by Cuvier after the Asteræ in the division Zoophytes.

"Nearly all these species appear to have been attached to the bottom of the sea, or to floating extraneous bodies."*

POLYPI.

I. Carnosa.—Polypi connected with a fleshy substance, and consisting of,

I. *Free; marine;* moving by the contraction or expansion of the fleshy part; form symmetrical; axis of the body supported by a bone contained in a sac.

Pennatula, Virgularia.

II. *Fixed or stationary.*

A. Polypiferous matter covering a solid axis; *a.* axis with stellular discs.—Lamellileræ.

b. Stellular discs terminal.

Sarcinula, Lithostrotion, Caryophyllea, Turbinolia, Cyclolites.

b b. Stellular discs aggregated.

Explanaria, Astrea, Porites, Pocillopora.

a a. Axis destitute of stellular discs. *b.* Axis corneus and flexible; polypiferous basis cretaceous; the axis with spines.

c. Polypi developed.—Gorgoniadæ.

Gorgonia, Primnoa.

c c. Polypi not developed.—Corallinadæ.

Iania, Corallina, Halimeda.

b b. Axis stony.

Isis.

B. *Polypiferous basis* destitute of a continuous solid axis. *a.* Polypi developed. *b.* With eight tentacula; the basis fibrous.

Lobularia, Cydonium, Cliona.

b b. Polypi with tentacula exceeding eight in number; basis nearly uniform.

Alcyonium, Cristatella.

a a. Polypi not developed.—Spongiadæ.

Tethya, Halichondria, Spongia, Grantia.

* Bridgewater Treatise, p. 417.

II. CELLULIFERA.

Polypi lodged in calcareous shells; imperforate at the base, and consisting of,

I. *Substance rigid stony.*

I. Cells in the form of minute pores, imbedded. MILLEPORADÆ.

Millepora.

II. Cells tubular and produced beyond the surface. TUBIPORADÆ.

Tubipora, Favosites, Tubulipora, Discopora, Filipora, Terebellaria.

III. Cells utricular, adjacent, or superimposed. ESCHARDÆ.

Eschara, Retepora, Cellepora, Berenicea, Hippothoa, Alecto.

II. *Substance flexible.* FLUSTRADÆ.

Farcimia, Flustra.

III. THECATA.

Polypi surrounded by a membraneous tube, covering the subdivisions of their compound body, and consisting of

I. *Sheath slightly calcareous; cells single, or in rows.*

Cells enlarged, in rows, united or single. CELLARIADÆ.

Cells united with the orifices opening on the upper surface.

Cellularia, Tricellaria, Crisia.

Cells in pairs, attached by the back, the orifices with opposite aspects.

Notamia.

Cells single.

Eucratia, Anguinaria.

II. *Sheath membranaceous, cells enlarged externally and lateral.* SERTULARIADÆ.

I. Base of the cells broad, coalescing with stem, and on opposite sides.

Sertularia, Dynamena, Thuiaria.

Cells unilateral.

Antennularia, Plumularia, Serialaria.

II. Base of the cells narrow or pedunculated.
Campanularia, Valkeria, Cymodocia.

III. Sheath membranaceous, cells simple, extremities of branches.—TUBULARIADÆ.
Tubularia, Plumatella.

IV. NUDA.

Polypi naked, the mouth with marginal tentacula.—Coryna, Hydra.

V. VIBRATORIA.

Polypi having the mouth furnished with vibrating hairs.*

We have thus, with great care, endeavoured to trace the line of separation between "the moving creature that hath life," and the Testaceous, Molluscous, and Zoophytic inhabitants of the ocean which are endowed with life, but not with the faculty of free and rapid locomotion, with as much distinctness and continuity as the state of information on that particular description of animal life will permit.

In conducting this investigation we have necessarily been actuated by the different relation in which we stand towards the existences which are ranged on the opposite sides of that distinguishing boundary line. "The moving creature that hath life" (more easily characterised by the possession of organs indicative of motion), not being essential as evidences to prove our future assumptions, we have, at once, discarded them from our attention and our memories; while, on the other hand, we have sought, by a detailed recapitulation of the various Classes, Orders, Tribes, and Genera—deduced from the authenticated and the most elaborate classifications of modern Conchologists—to arrest the attention, whilst we impressed the memory with particulars respecting those creatures actually ascertained to be, or which are considered on that side of the line which implies that either entire *immovability* or *restricted motion* is their lot; an additional labour which we have undertaken, not only with the design of more effectually separating those two divisions, but in order that, when we come to com-

* History of British Animals, pp. 472, 505—553.

pare the description of animals which we consider to be of primitive origin, with the fossil remains brought to light by geologists, we may be enabled to arrive at more satisfactory and more correct conclusions.

Perhaps, before we proceed to adduce more general evidence on the same point, a concise recapitulation of those Divisions and Classes of the Animal Kingdom which we consider incapable—in the full acceptation of the term—of free locomotion may be beneficial. They are as follow:—

Division II.

Class III.—Gasteropoda, *less* Pulmonata.
IV. Acephala.
V. Brachiopoda.
VI. Cirripeda.

Division III.

Class I.—Annelides. *Order*—Sedentariæ.

Division IV.

Class I.—Echinodermata.
IV. Polypi.

To which may be added several extinct families; such as the Productæ, Spirifer, Trilobites, Orthoceratites, Belemnites, and many others.

The following corroborating testimony is from the pen of Dr. Fleming, and although couched in general terms, is deserving of attention, considering the assiduity and success of his researches into this particular branch of natural history. He says—

"Besides possessing the faculty of sensation and voluntary motion, I likewise am able to move my limbs in such a manner as to change the position, not of one organ merely, but of my whole body, or to shift from one place to another. This new action is termed *Locomotion.* It requires for its performance, not merely the conditions requisite for sensation and voluntary motion, but likewise an arrangement of organs so constructed as by their action on the surrounding elements, whether of air, earth, or water, the body may be displaced. Quadrupeds, birds, reptiles, and fishes, possess such an arrangement of organs, and exhibit the locomotive power in a great degree of perfection. But as we descend in the scale, we find many

animals in which such an organization does not exist, and that live on the same spot from the commencement to the termination of their existence.

"Those animals, however, are all *natives of water*, and although they be thus stationary themselves, the fluctuations of the element in which they live produce a variety in the scene, and daily bring new objects in contact with their organs of sensation.

"Among the invertebral animals, in which the faculty of locomotion is not present in every species, there does not appear to be any link in the chain, or any system of organs connected with other functions, which regulate the presence or absence of locomotion. The *Monas*, usually considered as the lowest term of animal life, and in which neither mouth nor vessels can be perceived, is an animalcule which resides in water, and performs all its locomotive evolutions with considerable rapidity. The *Oyster*, on the other hand, in which a heart, bloodvessels, brain, gills, and stomach, may be easily observed, has one valve of its shell cemented to the rock, and depends on the bounty of the waves for all the objects of its sensation and nourishment.*

"The fourth method," continues Dr. Fleming, "termed *Cementation*, employed by animals to preserve themselves stationary, consists in a part of their own bodies being cemented to the substance on which they rest. This takes place in the common mussel, by means of strong cartilaginous filaments, termed the *byssus*, united in the body to a secreting gland, furnished with powerful muscles, and, at the other extremity, glued to the rock or other body to which it connects itself. In other cases, as in the oyster, the shell itself is cemented to the rock. This method of resisting the action of the disturbing forces of the air and the water is unknown among the vertebral animals. In the Mollusca it occurs in those with shells termed *byssiferous* and *fixed*. . . . . . Among the Zoophytes, the adhesion between them and the substance on which they grow is generally accomplished by means of a cement, connecting (as in nearly all animals fixed by cementation) their bodies for life to the spot where they first adhered.†

To close the evidence for this part of the argument, we only require to know upon what authority the extinct families of

* Philosophy of Zoology, by Dr. Fleming, &c., vol. i. pp. 46, 47.

† Ibid, pp. 129, 130.

Molluscous animals are to be considered as having been incapable of free locomotion. Direct proof of this is altogether unattainable: the very circumstance of their being extinct precludes the possibility of their nature and habits being thoroughly known; while every naturalist is aware of the danger of trusting to analogy for just inferences, particularly where fossil shells alone are left as the means of instituting the comparison. To proceed, however, with whatever indirect proof we can procure, we shall first ascertain what is said by geologists of the state in which the remains of the extinct mollusca are found; for to their researches is due the greater part of the knowledge we possess of fossil testacea.

"The organic character of the Zechstein approaches," says Sir Henry de la Beche, "as far as researches have yet gone, that of the next, or Carboniferous group; *Productæ*, which abound in the Carboniferous limestone, being not only discovered in the Zechstein, but also *Spirifers*, shells which also abound in the carboniferous limestone.*

"We next arrive, in the ascending order, to the Muschelkalk. We here have evidence that probably at the same epoch a deposit of calcareous matter took place, if not continuously, at least at various places from Poland to the south of France inclusive; and that the marine animal life distributed over this surface was nearly of the same kind. But it is a remarkable circumstance that this life was not identical with that which existed at the time when the Zechstein was formed; the organic character of the two rocks is distinct. . . . . . In whatever manner this may be considered, the fact appears certain, that circumstances had arisen, changing the character of marine life over certain portions of Europe; that certain animals abounding previously, and appparently for a great length of time (for, as will be seen in the sequel, they are enveloped in various thick and older deposits), have disappeared never to reappear, at least, as far as we can judge from our knowledge of organic remains.†

"The Grauwacke group occurs in Norway, Sweden, and Russia. It forms a portion of Southern Scotland, whence it ranges, with breaks formed by newer deposits, down Western England into Normandy and Brittany. It appears abundantly in Ireland. A large

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* Manual of Geology, 2nd edition, p. 406. † Ibid, p. 407.

mass of it is exposed in the district constituting the Ardennes, the Eifel, the Westerwauld, and the Taurns. Another mass constitutes a large portion of the Hartz mountains, while smaller patches emerge in other parts of Germany on the north of Magdeburgh, and other places. In all these situations there is, notwithstanding, small variations, a general and prevailing mineralogical character which points to a common mode of formation over a considerable area. From all the accounts, also, that have been presented to us by Dr. Bigsby and the American geologists, we have every reason to consider that a deposit closely agreeing in relative antiquity and in its general mineralogical and zoological characters exists extensively in North America; so that there is evidence to show that some general causes were in operation over a large portion of the Northern hemisphere, and the result was the production of a thick and extensive deposit enveloping animals of similar organic structure over a considerable surface.*

"In this catalogue (that of the organic remains of the grauwacke group) we find a mixture of existing and extinct genera, which is remarkable when we consider the great antiquity of the rocks containing them. . . . . . The most abundant shells belong to the genera *Orthoceratites*, *Producta*, *Spirifer*, and *Terebratula*. . . . .

"*Productæ* are common in this and the carboniferous groups, and existed during the deposit of the Zechstein. *Spirifers*, which also abounded during the deposit of the grauwacke and carboniferous series have been observed up as high as the lias, where three species of the genus Spirifer have been detected, one (Spirifer Walcotii) being a very common and characteristic shell. The *Terebratulæ*, which, even admitting the Swedish division, are found in the preceding series, if not in the higher part of this, extend upwards to the present day, many species being now known. Taking, therefore, this natural group as it existed at this early period, in which we should probably include the carboniferous limestone, and tracing it upwards through the various rocks, we find that the *Productæ* first disappeared and then the *Spirifers*, while the *Terebratulæ* have been preserved through all the changes which have taken place on the surface of our planet. . . . . . The *Trilobite* family seem now to have entirely disappeared from among existing animals, and we may, perhaps, venture to infer, from our present information respecting organic remains, that it became extinct before the *Productæ*; and we

* Manual of Geology, 2nd edition, p. 455.

are almost certain it ceased to exist long before the *Spirifers;* for neither in the muschelkalk nor in the lias has the smallest trace of them ever been detected.

"Unlike the *Trilobites*, the *Crinoidea* common in this early period are continued up to the present day, though the genera observed in the grauwacke series and in the carboniferous group seem to have disappeared previously to the deposit of the oolitic series, when other genera were called into existence, one of which, *Pentacrinites*, is discovered in the present seas . . . . .

"Among the corals will be found several genera now existing; and it deserves notice that throughout the series of fossiliferous rock, wherever there is an accumulation of polypifers, such as would justify the supposition of coral banks or reefs, the genera *Astrea* and *Caryophyllia* are present, genera which, according to the more recent observations of naturalists, in addition to *Meandrina*, and one or two others, are the principal architects of coral reefs at the present day."*

Professor Jameson, in his Illustrations of the Cuvierian Theory of the Earth, when treating of Werner's views of the natural history of petrefactions, mentions that

"He (Werner) first made the highly important observation, that different formations can be discriminated by the petrefactions they contain. It was during the course of his geognostical investigations that he ascertained the general distribution of organic remains in the crust of the earth. He found that petrefactions appear first in transition rocks. These are but few in number, and of animals of the Zoophytic or testaceous classes. In the older floetz rocks they are of more perfect species, as of fish and amphibious animals; and in the newest floetz and alluvial rocks, of birds and quadrupeds, or animals of the most perfect kind . . . . . He also was led to believe, from his numerous observations, that sea plants were of more ancient origin than land plants. A careful study of the genera and species of petrefactions disclosed to him another important fact, viz., that the petrefactions contained in the oldest rocks are very different from any of the species of the present time; that the newer the formation the more do the remains approach in form to the organic beings of the present creation; and that, in the very newest formations, fossil remains of the present existing species occur. He

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* Manual of Geology, pp. 469—471.

also ascertained that the petrefactions in the oldest rocks are much more mineralised than those in the newer rocks, and that in the newest rocks they are merely bleached or calcined."*

"It was remarked," says M. Alex. Brougniart, "more than a hundred years ago, that there almost always occurred differences between the shell fish and other animals which at present live in the seas and on the surface of the earth, and those which occur in a fossil state in all countries. This first view has been confirmed by a more detailed examination, and has by degrees led to another, which maintains that the deposits of organic remains buried in the crust of the earth are arranged, as it were, by successive generations, in such a manner that all the remains of any one deposit have a particular sum of resemblance to one another, and a general sum of difference with the deposits above and below it. It has also been thought, that this last sum becomes so much the higher, or the difference so much the greater, in proportion as the deposits are more distinct or more removed from one another in a vertical direction. This rule, which was at first cautiously assumed, and only for certain localities, has been found applicable to almost all the places observed in the different parts of the globe, and to all the remains of organized bodies buried in its beds, whether they belong to the class of animals or to that of vegetables. The exceptions which appeared to present themselves have either vanished under a more scrupulous examination, or have been explained by the discovery of particular circumstances which have given rise to them. Thus, in reducing this rule to the general exposition which we have made, it does not appear liable to any real objection, and all geologists are now agreed in thinking that the generations of organised bodies which have successively inhabited the surface of the earth, differ from the present generation in proportion as the *debris* are further removed from the surface of the earth, or, which nearly comes to the same thing, in proportion as the periods at which they have lived are more remote from the present time. It follows from the same rule, that this distinct succession of generations would present itself only in the structure of the crust of the globe. It would also of itself be sufficient to establish the fact, as has been remarked by M. Cuvier, that this crust has not been formed by a single operation. But this character of succession in the formation of the beds of the earth is frequently

* Jameson's Illustrations of Cuvier's Theory of the Earth, pp. 336—338.

associated with other very remarkable differences, such as the nature of rocks, their structure in the great scale, their known order of superposition, the minerals which accompany them, &c. &c. Now these mineralogical circumstances are almost always found in agreement with the characters which are taken from the general resemblance of organised bodies in deposits, considered as of the same formation from their geognostical characters; and they are also pretty constantly found in agreement with their difference in the opposite case."*

"Geologists have begun, of late years," says another writer, "to survey the structure of the earth in more minute and patient detail than their predecessors; to compare, by map and section, its most interesting provinces; to contemplate the individual facts directly, and not through the dark and distorting medium of a master's cosmogany; and to examine, with zoological skill, the organic inscriptions of its different strata. In thus studying to decypher the volume of its shelly records, they have explored many mysteries, inscrutable by Werner, Hutton, and others of their schools . . . . . . In this new field of knowledge, the English nation stands pre-eminent; against no mean rivalry, however, of the naturalists of France. Emulation has here produced the happiest effects; for while the mineral superpositions of England have received admirable illustration from the sagacity of Smith, Greenough, McCulloch, Conybeare, Phillips, Buckland, De la Beche, Webster, Weaver, Winch, and several other members of the London Society; Brougniart, and Von Buch, have revealed many wonders in French, Swiss, and Italian geology, and the two Cuviers, Blainville, Lamarck, and Defranee have thrown surprising light on the zoology of fossils. By directing his profound knowledge of comparative anatomy, to antediluvian osteology, Sir Everard Home has gathered fresh laurels; nor have the German and Italian mineralogists been forgetful of their fame in this difficult career. The joint labours of all these philosophers have been embodied by a master's hand, along with his own unrivalled studies in the *Ossemens Fossiles* of Baron Cuvier; a magnificient production of which, it is difficult to say, whether the science, eloquence, or candour, be most worthy of admiration.

" By such conspiring researches, an interesting gradation has been

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* Art. II. On fossil organic remains as a geognostic character, by Alexander Brougniart, Member of the Institute of France, &c. &c. in No. xvi. of Edin. Phil. Journal, pp. 226—228.

traced in the species of organic exuviæ distributed throughout the secondary strata, in their order of superposition. *Each successive mineral bed is the sepulchre of a peculiar colony of shell fish.* These relics of life have thus acquired singular importance. They furnish stereotype pages, so to speak, by which the corresponding or equivalent geological formations may be read and recognised in every terrestrial zone, however interrupted the mineral planes may be by ravines, mountains, or seas."*

Baron Humboldt states that,

"Nearly at the same period *Nicholas Stenon* first distinguished, 'the primitive rocks anterior to the existence of plants and animals on the globe, and consequently never containing any organic remains, from the secondary rocks superimposed on the former and filled with animal remains.' . . . . . .

"M. Brougniart (whose labours joined to those of MM. Lamarck, Defrance, Beudant, Desmarest, Prevost, Fernssac, Schlotheim, Wahlenberg, Buckland, Webster, Phillips, Greenough, Warburton, Sowerby, Brocchi, Soldani, Cortesi, and other celebrated mineralogists have so much advanced the study of *subterraneous conchology*), has recently pointed out the striking analogies which fossil bodies present in certain formations of Europe and North America. . . . . .

"Among the zoölogical characters applied to geognosy, the absence of some fossils often characterises formations better than their presence. This is the case with the transition rocks; we find, in general, only madrepores, encrimites, trilobites, orthoceratites, and shells of the family of terebratulæ; that is to say, fossils, of which some species not identical, though analogous, are found in very modern secondary beds, but in these transition rocks many other remains of organised bodies are wanting, which appear in abundance above the red sandstone."†

The following concise but concurring extracts deserve attention, not only on account of the diligence displayed by their author, but likewise from the recentness of his work, which warrants the assumption of the latest discoveries being referred to in it:—

* A New System of Geology, by Dr. Ure, pp. 47, 48.

† Geognostical Essay on the Superposition of Rocks, by Alex. de Humboldt. pp. 48, 57, 58.

"The first thing that strikes a geological naturalist," says Mr. Ansted, "in looking over the numerous fossils from the silurian rocks is the apparent want of fishes, and, indeed, of all vertebrated animals. Abundant proof is afforded that these rocks were formed at the bottom of water: some in shallow parts; others in the deepest recesses of the ocean, but nowhere throughout their wide spread in all parts of the world, have they yet yielded the smallest fragment that could be referred to a fish. It is, therefore, pretty clear, either that fishes had not been created, or that the conditions for their development were so unfavourable that they were extremely rare. . . . . Until the termination of the first great epoch, the silurian, there seem indeed only to have been introduced successive modifications and additional species of the *Invertebrated* type, and not until its close did the fishes appear, as if preparing the way for the next period marked by the prevalence of these more highly organised beings. . . . . It is important to remember, however, that almost all the great natural divisions of the Invertebrata began at once and together to perform their work on earth. . . . . . There is no appearance of any regular order of succession. . . . . . They seem to have been truly contemporaneous, and doubtless were introduced as the group best fitted to perform the functions of their existence."*

The following extract from the address at the opening of the Southampton meeting, by Sir R. J. Murchison, the President, so eloquent and conclusive in itself, bears so directly on the point we seek to establish, that we gladly introduce it amongst the others:—

"When our associate, Conybeare, reported to us at our second meeting, on the actual state and ulterior prospects of what he well termed the 'archæology of the globe,' he dwelt with justice on the numerous researches in different countries which had clearly established the history of a descent as it were into the bowels of the earth—which led us, in a word, downwards through those newer deposits that connect high antiquity with our own period, into those strata which support our great British coal-fields. Beyond this, however, the perspective was dark and doubtful—

Res altâ terrâ et caligine mersas.

Now, however, we have dispersed this gloom; and by researches,

* Ancient World, by Ansted, London, 1847, pp. 25, 47—51, 395, 396.

first carried out to a distinct classification in the British Isles, and thence extended to Russia and America, geologists have shown that the records of succession, as indicated by the entombment of fossil animals, are as well developed in these very ancient or palæozoic strata as in any of the overlying or more recently formed deposits. After toiling many years in this department of the science, in conjunction with Sedgwick, Lonsdale, De Verneuil, Keyserling, and others of my fellow-labourers, I have arrived at the conclusion, that we have reached the very genesis of animal life upon the globe, and that no further 'vestigia retrorsum' will be found, beneath the protozoic or lower silurian group in the great inferior mass of which no vertebrated animal has yet been detected, amidst the countless profusion of the lower orders of marine animals entombed in it."

We should scarcely be doing justice to our subject were we to close the evidence for this part without giving the following graphic attestation by an indefatigable and intelligent contemporary :—

"The fact seems especially worthy of remark," says Mr. Miller, "that the organisms of some of the newer formations differ entirely in widely-separated localities from their contemporary organisms, just as, in the existing state of things, the plants and animals of Great Britain differ from the plants and animals of Lapland or of Sierra Leone. A geologist who has acquainted himself with the belemnites, baculites, turrilites, and sea urchins of the cretaceous group in England and the north of France, would discover that he had got into an entirely new field among the hippurites, sphaerulites, and mummulites of the same formations in Greece, Italy, and Spain; nor, in passing to the tertiary deposits would he find less striking dissimilarities between the gigantic mail-clad megaletherium and huge mastodon of the Ohio and the La Plate, and the monsters, their contemporaries, the hairy mammoth of Siberia, and the hippopotamus and rhinoceros of England and the continent. In the more ancient geological periods, ere the seasons began, the case is essentially different; the contemporary formations when widely separated are often very unlike in mineralogical character, but in their fossil contents they are almost always identical. In these earlier ages the atmospheric temperature seems to have depended more on the internal heat of the earth, only partially cooled down from its original state, than on the earth's configuration, or the influence of the sun.

"Hence a widely-spread equality of climate, a green-house equali-

zation of heat, if I may so speak ; and hence, too, it would seem a widely-spread fauna and the same tribes of animals seem to have ranged over spaces immensely more extended than those geographical circles, in which, in the present time, the same animals are found native.

"The fossil remains of the true coal measures are the same to the westward of the Alleghany mountains as in New Holland, India, Southern Africa, the neighbourhood of Newcastle, and the vicinity of Edinburgh.

"And I entertain little doubt that, on a similar principle, the still more ancient organisms of the Old Red Sandstone will be found to bear the same character all over the world."*

The following remarkable and corroborative announcement with which Dr. Fleming concludes some lengthened expositions respecting the succession of animal life through several distinct geological epochs will, we are assured, be perused with much interest, and be relied upon as the sincere convictions of a theologian and naturalist, on whom we have already drawn largely for information, and who, while he dedicates the leisure moments allowed him from his pastoral duties to the advancement of science, inculcates sound religious doctrines into the minds of his people :†—

"It may be supposed by some that the preceding statements are at variance with the generally received interpretation of the account of the Creation as given by Moses *Four* successive creations and extinctions of animals and vegetables are here represented as having taken place previously to the existing order of things, and it is assumed that the present races of animals and vegetables, the companions of Man, did not exist on the globe during any of the antecedent epochs. But the most sincere friend of Revelation need be under no alarm, even should he be anxious to establish the authority of the Bible over a wider field than the Moral History of our race.

"If the sacred Historian be considered as referring to the earlier eras in the commencement of his narrative only, '*In the beginning* God created the heaven and the earth,' and to have contemplated,

* Old Red Sandstone, 3rd edition, pp. 197, 198.

† Dr. Fleming is now Professor of Natural History in the Free Church College at Edinburgh.

in what follows, the creation of the animals and vegetables of the Modern Epoch, it will be found that the deductions of science, and the records of inspiration harmonize, as the Word and Works of God must do, if rightly interpreted. The question, indeed, lies within very narrow bounds. Are the zoological and geological epochs established as *true* in science? If those who are qualified to judge shall pronounce in the affirmative, then must every *interpretation* of that brief portion of the sacred page inconsistent therewith be rejected as spurious, and the advocates of error consigned to occupy a page in the History of Prejudice along with the persecutors of Galileo."*

The following extracts, with which we shall conclude this branch of philosophical evidence, are from Mr. Lyell's *Principles of Geology*:—

"The French naturalists showed that the specific characters of fossil shells and vertebrated animals might be determined with the utmost precision, and by their exertions a greater degree of accuracy was introduced into this department of science. It was found that, by the careful discrimination of the fossil contents of strata, the contemporary origin of different groups could often be established, even where all identity of mineralogical character was wanting, and where no light could be derived from the order of superposition. . . . . . A close comparison of the recent and fossil species, and the inferences drawn in regard to their habits, accustomed the geologist to contemplate the earth as having been, at successive periods, the dwelling-place of animals and plants of different races. . . . . . By the consideration of these topics the mind was slowly and insensibly withdrawn from imaginary pictures of catastrophies and chaotic confusion, such as haunted the imagination of the early cosmogonists, and numerous proofs were discovered of the tranquil deposition of sedementary matter, and the slow development of organic life."†

". . . . . Brocchi has remarked, when hazarding some interesting conjectures respecting the 'loss of species,' that a modern naturalist had no small assurance, who declared 'that individuals alone were capable of destruction, and that species were so perpetuated that nature could not annihilate them, so long as the planet lasted, or, at least, that nothing less than the shock of a comet, or some

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* History of British Animals, by J. Fleming, D.D., &c., Minister of Flisk, pp. 16—18.

† Principles of Geology, vol. i. p. 82.

similar disaster could put an end to their existence.'* The Italian geologist, on the contrary, had satisfied himself that many species of testacea, which formerly inhabited the Mediterranean, had become extinct, although a great number of others, which had been the contemporaries of these lost races, still survived. He came to the opinion that about half the species which peopled the waters when the Sub-Appenine strata were deposited, had gone out of existence; and in this inference he does not appear to have been far wrong.†

"In reference to the organic remains of the different groups which we have named, we may say that about a thirtieth part of the Eocene shells are of recent species, about one-fifth of the Miocene, more than a third, and often more than a half of the older Pliocene, and 9-10ths of the newer Pliocene."‡

"No geologists," says the same accomplished writer, "who are in possession of all the data now established respecting fossil remains, will, for a moment, contend for the doctrine of successive development of animal and vegetable life, and their progressive advancement to a more perfect state, in all its detail, as laid down by Sir H. Davy. But naturalists not unacquainted with recent discoveries, continue to defend the ancient doctrine in a somewhat modified form. They say that in the first period of the world (by which they mean the earliest of which we yet have procured any memorials), the vegetation consisted almost entirely of cryptogamic plants, while the animals which co-existed were almost entirely confined to zoophytes, testacea, and a few fish. Plants of a less simple structure succeeded in the next epoch, when oviparous reptiles began also to abound. Lastly, the terrestrial flora became most diversified and most perfect when the highest orders of animals, the mammifera and birds were called into existence."§

By those full, impartial, and concurring evidences, it will have been sufficiently seen, as stated in a propositional form in the *hundred and thirty-third* Theorem, that several extinct families of testaceous and zoophytic animals have, by their petrified remains, been discovered by geologists to have become extinct; not in one formation only, but in a succession of

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* Necker, Phytozool. Philosoph. p. 21. Brocchi, Conch. Foss. Subap. tome i. p. 229.

† Principles of Geology, vol. ii. p. 133.

‡ Ibid. vol. iii. p. 59.

§ Ibid, vol. i. p. 168.

geological formations; not in one part alone of the surface of our planet, but in groups over its whole extent.

It may have occurred to some that we have been too elaborate in the evidences we have given of facts so well authenticated; but we have to remind them that the general position we have now taken up of the *primitive animal life having been restricted to beings* which were indifferent to light and atmospheric air, and either incapable, or almost incapable, *of locomotion* occupies rather a prominent part in the groundwork of our future reasoning, and, for the same cause, requires to be fully proven and well-secured. We, therefore, repeat the assertion, that throughout a succession of geological epochs, several numerous families of testacea and zoophyta have become extinct; and that this is found to be the case wherever the earth's surface has been adequately examined.

In continuation we shall recapitulate the *hundred and thirty-fifth* Theorem, *that when the* AUTHOR OF NATURE *creates an animal or plant, all the possible circumstances in which its descendants are destined to live are foreseen, and a corresponding organization is conferred upon it to enable the species to perpetuate itself as long as is consistent with His omniscient purposes, under all the circumstances to which it will inevitably be exposed.*

From such a self-evident proposition it is presumed that no one will be disposed to dissent. The admission of power and disposition to create, must be allowed to involve the power and the will to have over-ruled all concomitant circumstances, as far as was consistent with the general plan of creation.

Our conviction of the truthfulness of those two bodies of evidence derived from distinct sources, added to the particular character of that which has reference to the fact of the testacea and zoophyta having, by families and by epochs, become extinct, places us in rather a rigid dilemma. On the one hand, we cannot doubt the validity of their having become extinct; on the other, we cannot abate in any manner our dependence on the power and the care of a superintending Providence. To unravel the difficulty and to reconcile those points, while, at the same time, we bring out of the whole a corroboration of our assumption of the degrees of *immovability of the creatures*

which then encrusted the solid parts at the bottom of the primitive waters, will be the chief design of what we are now about to bring forward.

Satisfactorily to account for the extinction of those mollusca and zoophyta at several epochs and over the surface of this planet, we shall be under the necessity of adopting one of the two following inferences which alike presume the direct interference of the Deity, namely, either that they were entombed by a succession of vast and general revolutions of the earth's stratified surface, extending simultaneously over the whole circuit of the globe, and so completely extirpating several races of its living inhabitants, that not one escaped whereby its species might have been perpetuated; or, that it was merely a development of the plan of creation in Providence, which brought about their extinction, when they had performed the object of their being, *by exhausting the waters of those peculiar elements on which they could alone subsist.*

The former of these assumptions involves very many improbabilities, is at variance with the conclusions which are derived from the facts established by geologists, and is inconsistent with other general and prevailing laws of materialism; besides which, it is wholly incompatible with the principles of this theory (as we shall have occasion to prove in the sequel), to suppose that any such general and overwhelming revolution, or even any partial disturbance of the stratified envelopes of our sphere, ever took place, until, by the introduction of Light into the material universe, the earth was caused to rotate around its axis, and to occasion one mighty revolution amongst all the masses, which for ages previously had been accumulating in tranquillity at the bottom of its dark and atmosphereless circumfluent waters; and which, consequently, took place at a period long subsequent to that in which the animated immovable beings we are now treating of had ceased to live, and had been profoundly entombed beneath the successive depositions of strata from the associated elements of the primitive ocean.

The rejection, therefore, of that alternative reduces us to the necessity of adopting the other; and while we fully accord with the sentiments expressed in the *hundred and thirty-fifth*

Theorem, we feel assured, in the words of an eminent geologist, that "whatever the kind of animal life may have been which first appeared on the surface of our planet, we may be certain that is was consistent with the wisdom and the design which has always prevailed throughout nature, and that each creature was peculiarly adapted to that situation destined to be occupied by it."* At the same time, we feel as fully convinced that several tribes and families of animals of the lower orders have become altogether extinct. Their solid remains discovered in the strata sufficiently attest the fact.

But we have already seen in a former part of this chapter, "that the slightest trace of organization discoverable in any natural body, is a complete proof that life is, or at least once was, present in that body;" and, in continuation, that one of the necessary conditions of a living being is "that of generation, by which they continue the form of their species," and that "fixed forms, transmitted by generation, distinguish each species, determine the arrangement of the secondary functions assigned to each, and point out the part they are destined to perform on the great stage of the universe. That organized forms can neither produce themselves nor change their character. Life is never found separated from organization; and whenever the vital spark bursts into a flame, its progress is attended by a beautifully organized body."†

Now, we have undeniable proof, by means of fossil remains, that organization, and consequently the living principle, once existed; and, if the living principle, then the necessary conditions of life; and, if the necessary conditions of life, then the power, by generation, of transmitting the form of their species; and, if the form, then the arrangement of the secondary functions assigned to each, and the part they are destined to perform on the great stage of the universe.

Recurring, however, to what has been established by the unanimous conclusions of geologists and comparative anatomists, that, although endowed with all those requisites, nume-

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* De la Beche's Manual of Geology, 2nd edition, p. 476.

† For a corroboration of this definition see Messrs. Todd and Bowman on the Physiology and Anatomy of Man, vol. i. p. 10, et seq.

rous families of the lower class of animated beings *have ceased to exist*, are no longer found holding a place amongst the innumerable living forms which inhabit the surface of the earth, we take up these and ask, how can they be applied so as to prove that they were indifferent to light and atmospheric air, and, consequently, were not possessed of the faculty of free locomotion?

It has been asserted on the authority of those who have dedicated their attention to the subject, and we cordially subscribe to their assertions, "that there could be no organic change wrought in the animal by its own agency; that fixed forms transmitted by generation distinguish their species, and determine the arrangement of the secondary functions assigned to each." This, then, precludes the possibility of change in the conformation of animal form itself, and guards, at the same time, against the error of supposing that any transmutation took place from form to form. It also proves *that had the attendant circumstances remained unaltered, the existing animals must have continued to have lived, and to have transmitted their forms to their succeeding generations.* But they did not do so, therefore *there must have been a change*, and such a change in the surrounding medium from whence they drew their subsistence as to occasion their gradual decrease, and ultimately, to cause their utter extinction.

One of the fundamental principles of this theory is, that the introduction of animal life into the world during the non-rotatory period, was with the design of interposing animal vitality and secretion between the solid materials and the liquid waters; to disturb the chemical equilibrium to which the primitive fluid was ever prone to revert; to abstract certain earthy and acidulous elements held by it in combination, as shall be more fully shown in the sequel of this treatise; and to transform these ingredients into animal bodies and testaceous and zoophytic coverings, the direct tendency of which *was to effect a change in the constituent elements of the primitive ocean.* It must also be observed that, owing to the peculiarity of the concomitant circumstances, the ocean could not be replenished with the materials which were thus being absorbed from it, which were taken away once for all and trans-

formed at its base into other distinct substances, and thus they became fixed and stored up for the future designs of the provident Creator.

Any change once begun under such circumstances as are here alluded to, namely—a living active agency operating upon an unrenewable amount of material—could tend alone but to one result: *an exhaustion of the material on which the animal subsisted; and consequent thereon, an extinction of the animal itself.*

Another fundamental principle of this theory is, that neither the successive stratiform beds of rock deposited at the bottom of the primitive ocean nor the ocean itself were in a state of readiness to be transformed into their present condition until immediately before the first rotation of the earth; consequently *a succession of distinct vegetable and animal forms would be indispensable to bring both to that degree of perfection.* As one race of the latter exhausted its peculiar food and became extinct, another race would require to be willed into existence to occupy its place and to continue the labour of assimilation, purification, and solidification. If any races were so constituted as to subsist on that which remained in the waters during the whole protracted time from the beginning until the period of rotation (and we know that many elements did so remain), these races would exist through all the vicissitudes which necessarily extirpated others of more restricted assimilation.

While with reference to the employment of animal and vegetable agency for the purpose of simultaneously preparing the ocean and the earth's mineral crust, we may observe, that during the period in question and in an element such as water, which admits of its associated ingredients—on their equilibrium being disturbed—so easily to obey the laws of gravity and to take a downward tendency, the bottom of the ocean was, of all others, the most suitable position for the colocation of the multitudinous artificers which it had pleased the Creator then to employ. It was also the most benign, for the lowest stratum of water would be that in which the last particle of sustenance would be found by them. To have conferred the power of their going elsewhere in quest of what could not have been found, would, on the other hand, have been inconsistent

with our ideas of the Creator's goodness ; while it would have been positively inimical to His future plans, as we shall hereafter make manifest.

When we come, in regular sequence, to treat of the fossil vegetable remains of the era to which we now allude, it will be shown that there was a succession, likewise, of distinct *families of plants.* That the epochs of their existence are clearly demonstrated by their fossil remains which are discovered in the strata. That by this undoubted test it is known that in many instances they grew coevally with the existence of certain molluscous and zoophytic animals, likewise now extinct. That the greater part being furnished with roots, *they must have been attached to the bottom*, consequently, were fixed during the whole period of *their* existence to the spot where they once took root. From all these considerations we cannot recognize any reason why we should admit the fixity of the plants, and doubt or deny the degrees of immovability which we contend for in the other ; and the more so, as the absence in the animals of the usual organs necessary for locomotion is as direct a corroboration, though *negatively* so, in their case, as the *positive* proof of roots is in the case of plants. *Fixity* is the general law governing the latter ; hence the presence of organs adapted thereto is sufficient to complete the identity. *Motion*, on the other hand, is the general law of animal life ; therefore the *absence* of organs fitted to effect this must be admitted as a proof, equally valid, of their incapacity to fulfil the requirements of *their* general law of being.

It has been asserted, "that all the fixed animals of the present day are inhabitants of the water, whose fluctuations bring food within their reach :"* and, although this is very different from maintaining what the direct line of our argument would demand, that all animals which depend for food on the surrounding element *must, necessarily, be fixed*, yet, we feel assured, there is a sufficiency of presumptive proof scattered throughout the writings of geologists who have given the subject their earnest attention, to show that the extinct *molluscous* and *zoophytic* creatures which inhabited the profundity

* Dr. Fleming's British Animals.

of the primeval waters, were either fixed, or had not the faculty—in its usual general acceptation—of locomotion. How, otherwise, could such passages as the following be found in their pages ?—

"From our present information respecting organic remains, we may venture to infer that *Trilobites* became extinct before the *Productæ*. We are nearly certain they ceased to exist before the *Spirifers ;* for, neither in the Muschelkalk, nor in the Lias has the smallest trace of them ever been detected. . . . . . It is a remarkable circumstance connected with the coal measures of the south of England, that marine remains have not been detected in them. . . . . Which seems to show that there was something which prevented the presence of marine animals—a circumstance the more remarkable as we have seen that such animals abounded almost everywhere during the formation of the Carboniferous limestone."*

"All geologists are now agreed in thinking that the generation of organized bodies which have successively inhabited the earth, differ from the present generation in proportion as their *debris* are further removed from the surface ; or, as the period of their existence is remote from the present time."†

"These records of a former state of nature afford a sort of rude chronology, by whose aid the successive depositions of strata may be marked out, ... each characterized by some peculiarity which enables us to recognize the deposits of any period in whatever part of the world they are found ; . . . . . the order of succession appearing to have been the same in any part of the globe."‡

"The animal remains in the most ancient series of European sedimentary rocks, from the Grauwacke to the coal inclusive, consists chiefly of corals and testacea. . . . . . The number of organic forms which have disappeared from the oldest strata may be conjectured from the fact, that their former existence is, in many cases, revealed to us merely by the unequal weathering of an exposed face of rock, by which certain parts are made to stand out in relief.

"Out of 1,122 species of fossil testacea obtained from the Paris basin, 38 only can be identified with the species now living. . . . . Some of these thirty-eight species have a wide geographical range,

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* De la Beche, pp. 470, 430. † Alex. Brougniart. ‡ Sir J. Herschel.

when found recent; and are, therefore, fitted to exist under a variety of circumstances."*

And, lastly, we find the following passages in a recent work:—

"A very superficial glance at general natural history will show that, however great the difference may be between the groups characteristic of any two geological *periods* at the same spot, a difference therefore corresponding to a lapse of *time*, the distinction is equally marked at the present day, in living groups with respect to *space*. . .

"There is hardly any fact in natural history more distinctly the result of observation, or more valuable as suggesting a great law of nature, than the strictly co-ordinate relation which *space* and *time* bear to the development of organic existences. . . . . Their range in a fossil state was as considerable in a *vertical* direction as it is now *horizontally* with regard to the recent species."†

All of which passages—and many others of a similar bearing which might be collated from the writings of geologists—go to infer the restricted locality of the numerous races which are thus shown to have become extinct.

For, even were we to relax our confidence in the wisdom and benignity of the Creator, and suppose that—having willed those animal forms into existence, for the purpose of purifying the waters, draining them of certain ingredients, and locking up those, otherwise noxious, materials in a solid, insoluble form, at the bottom of the ocean; while they at the same time contributed layer by layer to the outer crust of the Earth—HE endowed them with faculties of locomotion, not only to impede the accomplishment of HIS own plans of infinite wisdom, by rendering uncertain the accumulation of their remains in any given locality, but to admit of their going in search of what the waters (by animal action and secretion) had been incapable of supplying!—we repeat, that were we even capable of adopting so improper a view as this would infer, we still would have to explain why, both in form and in the massiveness of their outward coverings, they were creatures apparently

* Lyell's Principles of Geology.

† Ancient World, by Ansted, pp. 381—387.

so ill adapted for locomotion, and how it could possibly happen, that throughout a width of surface, such as that occupied by the "coal measures of the south of England, no marine remains should ever have been detected,"* unless what we are so anxious to establish be conceded, namely, that animal life, which we know existed coevally, was restricted to forms which were either altogether deprived of the power of locomotion, or endowed with it in a very limited degree.

Thus, it would appear, that all the evidences, direct as well as presumptive, tend to prove this leading peculiarity with respect to the animal inhabitants of the waters which surrounded the globe during the period of non-rotation, while as yet there was no atmosphere, and "darkness was upon the face of the deep." In the sequel of this section we shall endeavour to show, the perfect adaptation of creatures such as testacea and zoophyta, for performing what was then in progress of execution—and at the same time we shall point out the incapability of forms possessing locomotion, in the plenary sense of the term—either to have performed that work, or to have existed in the then condition of the world.

Meantime, perhaps, the strongest light in which the question can be put—after what has been adduced—would be to imagine the difficulty attendant on any attempt to wrest the mass of evidence, which can be collected on the subject, so as to *sustain the opposite* position; to endeavour to prove, that the animals of the primitive ocean were possessed of the faculty of moving themselves, at will, from place to place; and that, too, when from the concomitant circumstances of the period alluded to, every part of the circumfluent ocean must have been as nearly as possible alike.

Before leaving this part of our subject, we would take occasion to point out with precision, that what has been said has had no reference whatever to the fossil remains of those extinct monstrous animals which have been discovered in the tertiary and other recent strata. They, too, have been extirpated by a fiat of the Omnipotent, but which originated, we firmly believe and hope, hereafter, satisfactorily to prove, from a very different cause.

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* De la Beche, 2nd edition, p. 439.

SECTION II.

THE ANIMAL EXISTENCES OF THE NON-ROTATORY PERIOD.

CHAPTER II.

Review of the progress made in the previous Chapter. Followed up by exhibiting the description of Fossil Animal Remains which have been discovered in the older formations. Consolidated Lists of their Exuviæ from the Chalk downwards. General Notices respecting the same. The whole compared with the Animal Remains which, by dependance on Scripture, might have been expected to have been disembedded from the older strata, and found substantially, and with few exceptions, to correspond. Some Explanations respecting the points of disagreement. Remains of Vertebrate Animals discovered in localities supposed to belong to the formations of the Anti-rotatory Period.

We have thus, step by step, and by the most careful investigation, reached another resting-place on our onward and upward course. At the previous stage we became acquainted with the necessary conditions of *animal life*, and wherein it differs from mere *vegetable existence.*

We are now assured by the concurring testimony of some of the most accomplished naturalists of the age, that several extensive and numerous sections of the animal kingdom are *entirely destitute of the faculty of locomotion*, and others of it, in its plenary signification; and consequently all alike independent of atmospheric air. In very many and very important instances this fact is spontaneously and directly asserted. In other cases it is as conclusively inferred; while, with respect to those extinct races where no direct proof can be adduced on either side, all the attendant circumstances of the several instances, and

the reasoning founded on them, concur in evidencing that they, too, pertain to that great division of *animals which live, but do not freely move:* completing, as we presume, by those concurring testimonies, the proofs in favour of the concluding part of the *hundred and thirty-first* Theorem: "*although it is extremely difficult to draw the line with perfect precision which separates the beings possessed of locomotion from those which are fixed, yet, such a distinction does actually exist, and is, therefore, capable of being delineated.*"

Were we seeking to establish the mere fact of the existence of animal forms destitute of the power of voluntary motion, we should here rest satisfied, and consider we had accomplished what we desired to do; but, when it is considered how studiously the whole division of creatures so constituted seem to have been excluded from the command, which, on the fifth day of the Mosaic week, called into existence "the moving creature that hath life;" and then take into account, how clearly and how conclusively we have been enabled, by the assistance of the most eminent and searching naturalists, to establish the fact of there being so many distinct tribes of *Testacea* and *Zoophyta*, which *did not, indeed could not, have sprung into being on the promulgation of that command* which called forth forms, possessing a faculty to which they cannot make pretension—there can be little hesitation in admitting that the *immovable creatures, and creatures with restricted power of motion, had been willed into existence before;* and, strange as the means may appear, that they, nevertheless, formed part of the agency employed by the Omniscient Creator "in the beginning, when He created the heavens and the earth." Nor should we permit any limitation of our own mental capacity so far to derogate from a just appreciation of the attributes of God as to hesitate in admitting this assumption, which our judgment, founded on the palpable evidence of the senses, so clearly demands. No man, endowed with reason, for an instant doubts or pretends to deny that the world in its finished state, with all its inhabitants, are the workmanship of God's hands; an irresistible concession which confessedly implies His power (when required for the accomplishment of ulterior plans), to have exercised what, to us, appears a minor degree of

creative energy; if, in reality, it *can* be considered a more restricted manifestation of wisdom and power, to have constrained a *simpler form* of animal life to work out and accomplish any portion of the great and progressive plan of the Creation! For, in fact, it sometimes occurs to us, that those who would undertake to prove that it implies, on the contrary, a greater display of power than to cause more complex animals to perform certain functions, would prevail in the argument.

Our next endeavour must be to follow up the 'vantage ground which we have gained, by exhibiting, from the compilations of geologists, the *classes*, *orders*, *genera*, and *species* of the fossil animal exuviæ discovered embedded in the strata; and, by comparing them with those which we have pre-supposed to have been, to exhibit the analogy which exists between the two—an accordance as perfect as the state of scientific research either warrants or renders desirable; for a nearer approximation, so far from being more conclusive, would, on the contrary, be indicative of a lesser degree of proof, "experience having taught" the most accomplished geologists of the day, "to appreciate, at their proper value, the numberless chances to which organic remains are subjected of being classed in geological catalogues, in situations very different from those which correspond to their true position in nature."*

Guided by this caution we shall proceed to display, in the sequel of this chapter, the satisfactory coincidence between the forms which really existed, and those which, by *a priori* deductions, we presumed would—in accordance with the progressive development of the great plan of Creation—be found embedded in the stratified formations of the earth's outer crust during its non-rotatory period.

According to the lists given in the most approved geological manuals, the following compose the animal organic remains found embedded in the rocks alluded to.† They are given in

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* MM. De la Beche and Lyell.

† The organic remains, of a testaceous character, pertaining to the *tertiary* formations, will be found fully detailed in Mr. Lyell's *Principles of Geology*. They occupy no less than 43 pages of the Appendix, and are well worthy of being referred to.

geological succession from the chalk formations downwards; and in a consolidated abstract.

OF THE CRETACEOUS GROUP.

Zoophyta.

	Species.		Species.		Species.
Achilleum . .	3	Manon . . .	5	Scyphia . .	7
Spongia . .	12	Spongus . .	2	Tragos . .	5
Alcyonium .	2	Choanites . .	3	Ventriculites .	3
Siphonia . .	2	Hallirhoa . .	1	Serea . . .	1
Gorgonia . .	1	Millepora . .	4	Eschara . .	10
Cellepora . .	7	Retepora . .	5	Flustra . . .	3
Ceriopora . .	20	Lunulites . .	1	Orbitolites .	1
Lithodendron .	2	Caryophillia .	2	Fungia . . .	3
Chenendopora .	1	Hippalimus .	1	Diploctenium .	2
Meandrina . .	1	Astrea . . .	14	Pagrus . . .	1
Nullipora . .	1	Turbinolia .	2		

Polypifers.—*Genera not determined.*

Radiaria.

	Species.		Species.		Species.
Apiocrinites .	1	Pentacrinites .	1	Cidaris . . .	10
Glenotremites .	1	Galerites . .	9	Clypeus . .	1
Asterias, not determined.					
Echinus . .	7	Clypeaster . .	3	Echinoneus .	4
Cassidulus . .	1	Ananchytes .	9	Spatangus .	29
Nucleolites .	10	Marsupites .	1		

Annulata.—Sedentaria.

Serpula, 9 species determined, and one not determined.

Cirripeda.

Pollicipes, 2 species.

Conchifera.

Magas Pumilus
Thecidea, 3 species
Terebratula, 53 species
Crania, 8 species
Orbicula, species not determined
Sphæra Corrugata
Trigonia, 11 species, and one not determined
Nucula, 11 species
Pectunculus, 3 species
Arca, 6 species, and one not determined

Podopsis, 6 species
Spondilus? Strigilus
Plicatula, 2 species
Pecten, 31 species, and one not determined
Lima Pectinoides
Plagiostoma, 15 species, and one not determined
Avicula Cærulescens, and another not determined
Inoceramus, 17 species, and one not determined
Gervillia Aviculoides, and two others
Crenatula Ventricosa
Hippurites, 7 species, and one not determined
Sphærulites, 9 species
Ostrea, 19 species
Hinnites? Dubuisoni
Exogyra, 5 species
Gryphæa, 9 species
Modiola, 2 species
Pachymya Gigas
Chama, 5 species
Cucullæa, 7 species, and one not determined
Cardita, 4 species, and one not determined
Cardium, 5 species
Venericardia, species not determined
Astarte Striata, and one species not determined
Pinna, 7 species
Mytilus, 4 species
Mytiloides Labriatus
Thetis, 2 species
Venus, 9 species
Lucina Sculpta
Tellina, 3 species, and one not determined
Corbula, 7 species
Crassitella Latissima & another
Lutraria, 2 species, and one not determined
Mya, 5 species
Teredo, species not determined
Pholas? Constricta
Fistulana Pyriformis

MOLLUSCA.

Dentalium, 5 species, and one not determined
Patella Ovalis, and one not determined
Pileopsis, species not determined
Helix Gentii
Auricula, 3 species
Melania, species not determined
Paludina Extensa
Ampullaria, 2 species, and one not determined
Nerita Rugosa
Natica, 2 species, and one not determined
Cassis Avellana
Dolium Nodosum
Eburna, species not determined
Voluta, 2 species
Nummulites, 2 species and one not determined
Solarium Tabulatum?
Cirrus, 4 species
Pleurotomaria, species not determined
Trochus, 10 species, and one not determined
Nautilus, 8 species, and one not determined

Vermetus, 4 species, and one not determined
Sigaretus Concavus
Delphinula, species not determined
Turbo, 4 species
Turritella, 2 species, and one not determined
Cerithum Excavatum, and one not determined
Pyrula, 2 species
Murex, 2 species
Pterocera Maxima
Rostellaria, 6 species, and one not determined
Strombus Papilionatus
Ammonites, 50 species
Actinocamax Verus
Scaphites, 3 species, and one not determined
Lenticulites, 2 species
Lituolites, 2 species
Planularia, 2 species
Nodosaria, 2 species
Belemnites, 6 species, and one not determined
Turrilites, 5 species, and one not determined
Baculites, 5 species
Hamites, 20 species
Fusus Anadratus
Miliolites, 2 species

Crustacea.

Astacus, 4 species, and one not determined
Pagurus Faujasii
Scyllarus Mantelli
Eryon, species not determined
Arcania, species not determined
Eytæa, species not determined
Coryster, species not determined

Pisces.

Squalus Mustelus? and Galeus?
Muræna Lewesiensis
Zeus Lewesiensis
Salmo Lewesiensis
Esox Lewesiensis
Amia? Lewesiensis
Fish, genera not determined
Fish, teeth and palates

Reptilia.

Mososaurus Hoffmanni
Crocodile of Meudon
Reptiles, genera not determined

"From an inspection of the foregoing list, it would appear that the remains of mammalia have not yet been detected in the cretaceous group."*

OF THE WEALDEN ROCKS OF ENGLAND.

Conchifera and Mollusca.

Carduim Turgidum? and one not determined
Unio, 5 species
Succinea?

* Manual of Geology, by H. T. de la Beche, 2nd edition, pp. 271—297.

Pinna?
Venus?
Ostrea, species not determined
Cyclas, 3 species, and one not determined
Paludina, 3 species
Potamides, species not determined
Melania, 2 species

Pisces.

Lepisosteris, Silurus, and remains of fish, genera not determined.

Crustacea.

Cypris Faba.

Reptilia.

Crocodilus Priscus, and a species not determined
Leptorynchus
Iguanodon
Megalosaurus
Reptiles of the genera Trionyx, Emys, Chelonia, Plesiosaurus, and Pterodactylus
Tortoise *

FOSSIL ORGANIC ANIMAL AND ZOOPHYTIC REMAINS OF THE OOLITIC GROUP.

Zoophyta.

Achilleum, 6 species
Manon, 3 species
Scyphia, 39 species
Tragos, 9 species
Spongia, 2 species, and one not determined
Alcyonium, species not determined
Fungia Orbiculites, and one species not determined
Cyclolites Elliptica, and one species not determined
Turbinolid Dispar, and one species not determined
Turbinolopsis Ochracea
Cyathophyllum, 2 species
Meandrina, 3 species, and one not determined
Ceriopora, 9 species
Agaricia, 3 species
Lithodendron, 2 species
Caryophyllia, 8 species
Anthophyllum, 3 species
Astrea, 20 species, and one not determined
Aulopora Compressa
Entalophora Cellarioides
Favosites, species not determined
Spiropora, 4 species
Eunomia Radiata
Crysaora Damæcornis, and another
Theonoa Chlathrata
Idmonea Triquetra

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* Manual of Geology, pp. 303—305.

Cnemidium, 9 species
Limnorea Mammillaris
Siphonia Pyriformis
Myrmecium Hemisphæricum
Gorgonia Dubia
Millepora Dumetosa, and 6 others
Madrepora, species not determined
Eschara, species not determined
Cellepora, 2 species, and one not determined
Retepora ?
Flustra, species not determined
Alecto Dichotoma, and one species not determined
Berenicea Diluviana, and one species not determined
Terebellaria, 2 species
Cellaria Smithii
Thamnasteria Lamoarouxii
Explanaria Mesenterina, and one species not determined
Polypifers, genera not determined

RADIARIA.

Cidaris, 18 species, and one not determined
Cidaris (spines of)
Echinus, 6 species, and one not determined
Galerites, 3 species
Clypeaster Pentagonalis, and one species not determined
Nucleolites, 6 species, and one not determined
Ananchytes Bicordata
Spatangus, 4 species, and one not determined
Solanocrinites, 3 species
Comatula, 4 species
Clypeus, 6 species, and one not determined
Echinites, genera not determined
Echinites (spines of)
Ophiura Milleri and 2 others
Encrinites, 2 species
Eugeniacrinites, 5 species
Apiocrinites, 8 species
Pentacrinites, 14 species, and one not determined
Crinoidea, genera not determined
Rhodocrinites Echinatus
Asterias, 8 species

ANNULATA.

Serpula Squamosa, with 49 other species determined, and one not determined.
Lumbrionia, 6 species

CONCHIFERA.

Spirifer Walcotii
Delthyris, 2 species
Terebratula Intermedia, and 56 other species
Orbicula Reflexa and 2 species, and one not determined
Hippopodium Ponderosum
Isocardia, 7 species, and one undetermined
Cardita, 3 species, and one undetermined
Cardium, 11 species

Lingula Beanii
Ostrea, 22 species, and one not determined
Exogyra Digitata? and one undetermined
Gryphæa, 14 species
Plicatula Spinosa
Pecten, 20 species
Plagiostoma, 17 species, and one undetermined
Myoconcha Crasa
Posidonia Bronni
Lima, 10 species, and one undetermined
Avicula, 11 species
Inoceramus Dubius
Gervillia, 7 species, and 1 not stated
Perna, 3 species, and one undetermined
Crenatula Ventricosa, and one undetermined
Trigonellites, 2 species
Pinna, 6 species, and one undetermined
Mytilus, 5 species, and one undetermined
Modiola, 19 species, and one undetermined
Nucula, 9 species, and one not determined
Pectunculus, 2 species
Arca, 6 species, and one not determined
Cucullæa, 13 species, and one not determined
Astarte, 12 species, and one undetermined
Venus, species undetermined
Cytherea, 4 species, and one undetermined
Pullastra, 2 species, and one undetermined
Donacites Alduini
Corbis, 2 species
Tellina Ampliata
Psammobia Lævigata
Lucina, 3 species, and one undetermined
Sanguinolaria, 2 species, and one undetermined
Corbula, 4 species, and one undetermined
Crassina, 7 species
Mactra Gibbosa
Amphidesma, 5 species
Lithodomus, species not determined
Chama, 2 species, and one undetermined
Unio, 7 species
Trigonia, 13 species, and one undetermined
Lutraria Jurassi
Gastrochæna Tortuosa
Mya, 8 species
Pholadomya, 16 species, and one undetermined
Panopæa, 2 species
Pholas, 2 species

MOLLUSCA.

Dentalium Giganteum, and Cylindricum, and one species undetermined
Patella, 7 species
Emarginula Scalaris
Ampullaria, species not determined
Natica, 5 species, and one undetermined
Nerita, 4 species

Pelcolus Plicatus
Ancilla, species not stated
Bulla Elongata
Helicina, 4 species
Auricula Sedgvici
Delphinula, species not determined
Solarium, 2 species
Cirrus, 5 species, and one undetermined
Trochus, 21 species, and one undetermined
Rissoa, 4 species
Turbo, 9 species, and one undetermined
Phasianella, 2 species
Turritella, 5 species, and one undetermined
Nerinea Tuberculata, and one species undetermined
Cerithium, 2 species, and one undetermined
Planorbis Euomphalus
Melania, 4 species, and one undetermined
Paludina, species not determined
Pleurotomaria, 2 species
Tornatilla, species not determined
Vermetus, 2 species, and one undetermined
Buccinum Unilineatum, and one species undetermined
Myoconcha Crassus
Terebra, 4 species
Belemnites, 28 species, and one undetermined
Hammites, species not determined
Orthoceras Elongatum
Nautilus, 10 species, and one not stated
Ammonites, 172 species
Trigonellites, 4 species
Onychoteuthis Angusta
Murex, 2 species
Rostellaria, 4 species, and one undetermined
Pteroceras Oceani, 3 species
Actæon, 5 species, and one undetermined
Loligo, 2 species
Sepia Hastiformis, with remains of ink bags
Sepia, beaks or Rhyncolites

Crustacea.

Pagurus Mysticus
Eryon, 2 species
Syllarus Dubius
Palæmon, 3 species
Astacus, 3 species, and one undetermined
Crustacea, not yet determined

Insecta.

Insects of the Libellula family
Elytra of Coleopterous insects

Pisces.

Dapedium Politum
Clupea Sprattiformis
Fish, species not yet determined
Fish, palates and teeth
Ichthyodorulites of different kinds

Reptilia.

Pterodactylus, 7 species, and one unknown
Crocodilus, 2 species
Gavial, 2 species
Crocodile of Mans, and remains not determined .
Tileosaurus
Megalosaurus Bucklandi, and a species not known
Racheosaurus Grasilis
Geosaurus Bollensis
Lacerta Neptunia
Plesiosaurus, 6 species, and one undetermined
Ichthyosaurus, 4 species, and one undetermined
Saurian bones
Tortoise, in Stonesfield slate

Mammalia.

Didelphis Bucklandi.*

ORGANIC REMAINS OF THE MUSCHELKALK.

Reptilia.

Plesiosaurus, Ichthyosaurus, and a great Saurian genus not determined.

Crustacea.

Palinurus Sueurii.

Mollusca and Conchifera.

Nautilus Bidorsatus
Ammonites, 3 species
Buccinum Obsoletum
Turritella Terebralis
Dentalites, 2 species
Terebratula, 4 species
Trigonia, 2 species
Mytilus, 2 species
Myacites, 4 species
Pecten Reticulatus
Ostrea Spondyloides
Cardium Striatum
Plagiostoma, 4 species
Avicula Sociales

Annulata.

Serpula, 2 species

Radiaria.

Two species of Encrinites.
Ophiura, 2 species
Asterias Obtusa †

ORGANIC REMAINS OF THE RED OR VARIEGATED SANDSTONE.

"M. Elie de Beaumont notices that at Domptail (Vosges) this

* Manual of Geology, 2nd edition, pp. 332—380.

† Ibid, pp. 393, 394.

rock contains abundantly the casts of shells, for the greater part of the same genera, and even of the same species, as those discovered in the Muschelkalk. And M. Voltz remarks, that the red sandstone of the Vosges presents the following shells:—*Terebratula*, Trigonia, Pecten, Plagiostoma, Avicula (Mytilus), Sociales, Turritella? Natica?"*

ORGANIC REMAINS OF THE ZECHSTEIN AND COPPER-SLATE.

Reptilia.

Monitor of Thuringia.

Pisces.

Palæothrissum, 6 species, and one undetermined

Fish, genera not determined

Mollusca and Conchifera.

Turbo?
Pleurotomaria?
Melania? 5 species
Ammonites, species not determined
Axinus Obscurus
Arca Tumida
Cucullæa Sulcata
Avicula Gryphæoides
Ostrea, species not determined
Astarte?
Producta, 7 species
Spirifer, 4 species
Terebratula, 8 species, and one undetermined
Modiola Acuminata, and one species undetermined
Mytilus Squamosus
Pecten, species not determined
Plagiostoma?
Venus?

Radiaria.

Cyathocrinites Planus, Encrinites, and Crinoidea; genera not determined.†

Zoophyta.

Retepora Flustracea, and ditto Virgulacea; Polypifers, genera not determined.

ORGANIC REMAINS OF THE COAL MEASURES.

Conchifera.

Pentamerus Knightii
Lingula Striata
Unio, 2 species
Nucula, 2 species

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* Manual of Geology, 2nd edition, p. 395.

† Ibid, pp. 397—399.

Vulsella Elongata and Breois
Pecten, 2 species
Mytilus Crassus
Saxicava Blainvillii
Hyatella Carbonaria
Mya, 3 species

MOLLUSCA.

Euomphalus Pentangularis
Turritella, 2 species
Bellerophon, 2 species
Orthoceratites, 5 species
Nautilus?
Ammonites, 6 species

PISCES.

Ichthyodorulites, and fish palates.*

ORGANIC REMAINS OF THE CARBONIFEROUS LIMESTONE.

ZOOPHYTA.

Millepora, 5 species
Cellepora Urii
Retepora Elongata
Caryophyllia, 7 species
Fungites, 2 species
Turbinolia, 5 species
Cyathophyllum Excentricum
Meandrina, species not determined
Astrea, 2 species
Catenipora, 5 species
Tupipora Tubularia
Syringopora Cæspitosa
Calamopora Polymorpha
Favosites, 4 species
Lithostrotion, 3 species
Amplexus Coralloides
Polypifers, genera not determined

RADIARIA.

Pentremites, 3 species
Platycrinites, 7 species
Actinocrinites, 5 species
Milocrinites Hieroglyphicus
Potereocrinites, 2 species
Rhodocrinites Verus
Cyathocrinites, 2 species

ANNULATA.

Serpula, Lithuus, and Compressa.

MOLLUSCA.

Pentamerus, 3 species
Spirifer, 22 species
Terebratula, 25 species
Crania Prisca
Producta, 28 species
Modiola Goldfussii
Nucula Palmæ
Arca Cancellata
Chama? Antiqua
Hippopodium Abbreviatum

* Manual of Geology, 2nd edition, pp. 419, 420.

Vulsella Lingulata
Ostrea Prisca
Hinnites Blainvillii
Pecten, 3 species
Mytilus Minimus
Cypricardia? Annulata
Cardium, 3 species
Tellina Lineata
Sanguinolaria Gibbosa
Megalodon Cuculatus

Conchifera.

Patella Primigenus
Planorbis Æqualis
Natica, 4 species
Melania, 2 species
Ampullaria, 2 species
Melanopsis Coronata
Nerita, 3 species
Turbo, 5 species
Helix? Cirriformis
Turritella, 2 species
Buccinum, 5 species
Bellerophon, 8 species
Conularia, 2 species
Orthoceratites, 18 species
Pyramidella Antiqua
Delphinula, 8 species
Cirrus, 2 species
Euomphalus, 13 species, and one undetermined
Pleurotomaria Delphinulata
Trochus Catenulatus
Nautilus, 9 species
Ammonites, 3 species

Crustacea.

Calymene, 4 species, Asaphus Cordatus, Paradoxicus Spinulosus, Trilobites, genera not determined.

Pisces.

Ichthyodorulites, and Tritores or fish palates.*

ORGANIC ANIMAL AND ZOOPHYTIC REMAINS OF THE GRAUWACKE GROUP.

Zoophyta.

Manon, 2 species
Scyphia, 4 species
Tragos, 2 species
Gorgonia Antiqua
Madrepora, species undetermined
Stromatopora Concentrica
Cellopora Antiqua, and one species undetermined
Retepora, 2 species, and one undetermined
Astrea Porosa, species undetermined
Columnaria Aveolata
Catenipora, 3 species, and one undetermined
Syringopora Verticillata
Tubipora, species not determined
Calamopora, 7 species
Aulopora, 4 species
Agaracia Lobata

* Manual of Geology, 2nd edition, pp. 421—429.

Ceriopora Verrucosa, and 4 others
Flustra, species not determined
Anthophyllum Bicostatum
Turbinolia, species not determined
Cyathophyllum Dianthus, and 16 other species
Strombodes Pentagonus
Lithodendron Cæspitosum
Caryophillia, species not determined
Favosites, 5 species
Mastrema Pentagona
Amplexus Coralloides, and one species undetermined

RADIARIA.

Actinocrinites, 7 species, and one undetermined
Cyathocrinites, 4 species, and one undetermined
Platycrinites, 4 species
Rhodocrinites Verus and 4 others
Sphæronites, or Echinosphærites, 4 species
Penticrinites Prisus
Cuprosocrinites, 2 species
Milocrinites, 2 species
Euglinacrinites Mespiliformis
Eucalyptocrinites Rosacius

ANNULATA.

Serpula, 4 species

CONCHIFERA.

Thecidea? Antiqua
Spirifer, 18 species
Terebratula, 23 species
Strygocephalus, 2 species
Calceola, 2 species
Strophomena, 6 species
Producta, 12 species
Gryphæa, species not determined
Pecten, and 2 not determined
Plagiostoma, species not determined
Megalodon Cucullatus
Trigonia, species not determined
Cardium, 6 species
Cardita, 4 species
Isocardia, 2 species
Cypricardia?
Posidonia Becheri

MOLLUSCA.

Patella, species not determined, and 3 more in doubt
Peleopsis Vetusta
Melanopsis Coronata
Melania, 2 species
Natica, species undetermined
Nerita, species undetermined
Solarium Fasciatum
Cirrus Acutus
Pleurotomaria Cirriformis
Delphinula Æquilatera
Turritella Abbreviata, and one undetermined
Murex? Harpula
Buccinum, 4 species
Bellerophon, 8 species, and one undetermined
Orthoceratites, 29 species, and one undetermined
Cyrtoceratites, 4 species

Eumophalus Catillus, and three others, and one undetermined	Lituites, 2 species
Trochus Ellipticus	Nautilus, 9 species (3 are called *Ellipsolites* by Sowerby)
Turbo Bicarinatus, and 2 others	Ammonites, 3 species, and one undetermined
Conularia, 3 species, and one undetermined	

CRUSTACEA. TRILOBITES.

Calymene, 13 species	Ampyx Nasutus
Asaphus, 16 species	Olenus Bucephalus
Oxygia, 4 species	Agnostus Pisiformis
Paradoxides Tessini, and 4 others	Isotelus, 2 species
Nileus Armadillo, and Glomerinus	Trilobites, species not determined
Illænus, 3 species	

PISCES.

Ichthyodorulites, Fish bones and a tooth; and casts referable to vertebræ of fish.*

"Even yet," says Mr. Hugh Miller, "after many thousand Trilobites have been carefully examined, it remains a question with the oryctologist, whether this crustacean of the earlier period was furnished with legs, or creeped on an abdominal foot like the snail."†

We could bring forward innumerable other catalogues and lists of animal exuviæ, found to have been embedded in the imperishable mineral coatings with which the earth was successively invested while as yet it lay extended at the bottom of the dark and atmosphereless abyss of water by which it was everywhere surrounded during its non-rotatory period. "These marks," as Sir John Herschel so appropriately expresses himself, "of a former state of nature, so wonderfully preserved (like ancient medals and inscriptions in the ruins of an empire) which afford a sort of rude chronology by whose aid the successive depositions of the strata in which they are found, may be marked out in epochs more or less definitely terminated;"‡ but we suppress them as they would only be repetitions of those we have

* Manual of Geology, 2nd edition, pp. 455—469.

† New Walks in an Old Field, p. ix.

‡ Discourse on Nat. Philos. Cab. Cyc. p. 284.

given from the pains-taking and indefatigable geologist, M. de la Beche, and would, on that account, lend little assistance in the way of conviction; while they might clog the memory and embarrass the attention.

A comparison of the description of animals which the lists of organic remains now given reveals to us as having tenanted the bottom of the primitive ocean during the earliest geological epochs, with those which we concluded would be found there, affords an additional confirmation of the correctness of our views, inasmuch as it makes apparent the remarkable coincidence which, in general, exists between the one and the other.

Confiding implicitly in the announcements of Scripture, we were induced to apply to it, and ask—What description of animal life should be found inhabiting the primeval ocean previous to the formation of the light, and before the Earth revolved around its axis? The clear and unhesitating reply was—All, except "*the moving creature that hath life*" *dependent on light and air*; for these were subsequently created.

With this answer fresh on the memory, we turned to those naturalists who have given the subject a life-time's attention, and said to them—"Scripture, in whose assertions we repose perfect confidence, informs us that the living beings which inhabited the world's ocean before the introduction of light into the material universe, and ere the Earth revolved round its axis, must have consisted alone of those which are either *deprived of locomotion, or possess that faculty restrictedly*. Do you know of any such? what are they? and where do they usually dwell?" The ready and precise answer to those enquiries was—"We do know of many tribes of animals, some of which are totally incapable of locomotion, while others possess it only in a slight degree. They are all inhabitants of the water; and we have classed them under the distinctive groups of *Zoophyta*, *Radiaria*, *Conchifera*, and *Mollusca*."

Assured by this impartial and spontaneous testimony that numerous families of creatures of the description sought actually exist, that they are all exclusively inhabitants of the water; and, having learned their distinctive congregate appellations, we passed on to another department of the learned and the

laborious in research, and entreated them to inform us, what description of animal life do the petrified remains which they have met with embedded in the successive layers of the earth's outer crust, reveal to them to have chiefly inhabited the water, during the period when those rocks were being deposited and indurated. The reply which they gave us, after referring to the tabulated lists which they had compiled during their geological investigations, has just been submitted, and is found to be, as near as possible, a counterpart of the answer received to our previous enquiry.

The majority of the living forms made known to us by their exuviæ seem to have belonged to that great division which inhabits the water, and are either wholly *incapable of locomotion, or whose motions are restricted;* and, when reduced to scientific classification, they range themselves, with a few exceptions, under the orders *zoophyta, radiaria, conchifera, and mollusca.* But, notwithstanding that by this a general conviction of identity is borne in upon the mind, and leads to so much satisfaction; yet, as we have said above, when we run the eye over the consolidated lists of animal remains, we neither can conceal from ourselves, nor will it escape the penetration of others, that there are serious difficulties to be got over, or to be satisfactorily explained, before the reconciliation can be considered thoroughly complete.

Although comparatively few, and some even of doubtful classification, yet there do appear attached to the bottoms of all lists of organic remains, the names of animals which, during lifetime, were possessed of the power of free and swift locomotion; and, therefore, to the amount of the proof which they afford, contribute to weaken the evidence of those lists—full and complete as they are in every other respect—in favour of the position we are so desirous to establish. They are like "the dead fly in the ointment," which must either be got rid of, or it will spoil the whole. Another difficulty also exists, though not so manifestly, on the face of the evidence adduced, and which might, therefore, escape the observation of our general readers, did not prudence and candour induce us to be the first to point it out. We allude to the apparent contradiction which arises from supposing that the primitive ocean

was not composed of *salt water*, whilst the *radiaria, zoophytic, conchiferous, and molluscous exuviæ* discovered in the strata are analogous to the testaceous envelopes of similar animals which now inhabit our present seas, implying a seeming incompatibility between the habits of these two divisions of animal life—the ancient and the modern.

The former, and by far the most formidable difficulty, seems divisible into two distinct parts. First, that which respects animals whose powers of locomotion, from our imperfect knowledge of their construction, cannot be thoroughly ascertained, though no doubt can be attached to their geological position and era; and, secondly, as regards animals whose organs of motion are so perfect, and whose habits are so well known, that no doubt can be entertained as to their power of moving freely from place to place, although their geological position may, for the same reason, be exposed to doubt, and open to discussion. We shall, in the first instance, occupy ourselves with the ultimate division of the case, and after making some brief preliminary remarks, leave the discussion in the hands of those who are better qualified by their experience to conduct it; while we claim the full benefit of whatever reasoning we may find in geological works upon the subject; inasmuch as the advantage is clearly on the side of those who contend in favour of the *certainty* of locality and geological epoch of fixed animals, or of such as are of slow and imperfect motion, whose remains can only be found associated with the strata amongst which they had their residence when in life; while, on the contrary, the remains of animals which were capable of moving freely and rapidly from place to place might be, and no doubt are, discovered embedded in localities indicative of great divergency in *geological* epoch from that which had witnessed their living existence on the earth; and, from the same cause, have become greatly misplaced in geological chronology. This will appear much more apparent after having heard the evidences we intend to bring forward, and, having learnt in whose hands we design to leave the case, assured that when their attention has been directed to the point, they will do every justice to the subject, and treat it with the most truthful impartiality.

While, as an earnest of what may be expected, we have much pleasure in giving the following short extracts from some recent works on the subject:—

"We shall now," says Mr. Lyell, "consider in what manner the remains of animals may become preserved in rents or cavities. . . . .

"As the caves and fissures may remain open throughout periods of indefinite duration, and may become the receptacles of the remains of species inhabiting a country at very different epochs, it requires the utmost care to avoid confounding together the monuments of occurrences of very different dates. Dr. Buckland, in his indefatigable researches into this class of phenomena, has often guarded with great skill against such anachronisms, pointing out the comparatively recent preservation of some organic relics which have become mingled in a common tomb with those of older date.

"Fissures are very common in calcareous rocks, and they are, usually, in the course of ages, filled up in part by small, angular fragments of limestone, which scale off under the influence of frost and rain. Vegetable earth and land shells are washed in at the same time, and the whole mass often becomes cemented together by calcareous matter dissolved by rain water, or supplied by mineral springs. In an uncultivated country the edges of such fissures are usually overgrown with bushes, so that herbivorous animals, especially when chased by beasts of prey, or when carelessly browsing on the shrubs, are liable to fall in and perish. Of this kind is a fissure still open in Duncombe Park, in Yorkshire, where the skeletons of dogs, sheep, goats, deer, and hogs, have been found lodged upon different ledges that occur at various depths in a rent of the rock descending obliquely downwards.

"Above the village of Selside, near Yugleborough, in Yorkshire, a chasm of enormous, but unknown depth occurs in the scar-limestone, a member of the carboniferous series. 'The chasm,' says Professor Sedgwick, 'is surrounded by grassy shelving banks; and many animals, tempted towards its brink, have fallen down and perished in it. The approach of cattle is now prevented by a strong lofty wall, but there can be no doubt that, during the last two or three thousand years, great masses of bony breccia must have accumulated in the lower part of the great fissure, which probably descends through the whole thickness of the scar-limestone to the depth of perhaps five or six hundred feet.'*

* Principles of Geology, vol. ii. pp. 225—227.

"There is, however," continues the same gentleman, "as yet, no well authenticated instance of the remains of a saurian animal having been found in a member of the carboniferous series." And in a note he adds, "It is, indeed, stated that, among other fossils collected from the mountain limestone of Northumberland, the Rev. Charles V. Vernon Harcourt has been fortunate to find a saurian vertebra, together with patellæ and echinal spines, and an impression of a fern analogous to those of the coal measures in the mountain limestone. (Annual Report of the Yorkshire Phil. Soc. for 1826, p. 14.) But I am informed by Mr. Harcourt himself that the vertebra was discovered in loose alluvium."*

And in a subsequent part of his work, Mr. Lyell further mentions—

"It will appear evident, from what we have said in the second volume respecting the fossilization of terrestrial species, that the imbedding of their remains depends on rare casualities, and that they are, for the most part, preserved in detached alluvions, covering the emerged land, or in osseous breccias and stalagmites formed in caverns or fissures, or in isolated lacustrine formations. These fissures and caves may sometimes remain open during successive geological periods, and the alluvions, spread over the surface, may be disturbed again and again, until the mammalia of successive epochs are mingled and confounded together. Hence we must be careful when we endeavour to refer the remains of mammalia to certain tertertiary periods, that we ascertain, not only their association with testacea of which the date is known, but, also, that the remains were intermixed in such a manner as to leave no doubt of the former existence of the species."†

Sir Henry de la Beche says—

"By some it will be considered that too much space has been allotted to lists of organic remains in the following pages; . . . . . for practical purposes, however, there was no alternative between rendering them as perfect as the author's means of information would permit, or of omitting them altogether. It must, however, be confessed that, though constructed, apparently, from the best authorities,

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* Principles of Geology, vol. i. p. 148.

† Manual of Geology, 2nd edition, vol. iii. p. 60.

these lists require severe examination; for, unfortunately, the study of organic remains is beset with two evils, which, though of an opposite character do not neutralize each other so much as at first sight might be anticipated; the one consisting of a strong desire to find similar organic remains in supposed equivalent deposits, even at great distances; the other being an equally strong inclination to discover new species.

"There can be little doubt that from these and other sources of error, the same organic remains, particularly shells, often figure in our catalogues under two names; and that the exuviæ of certain animals are marked as discovered in situations where they have never been found. Notwithstanding these difficulties, it will, however, be evident, from a glance at the catalogues of organic remains, that a great mass of information has been gradually collected on this subject alone, from which the most important results must follow, even though the various lists may require considerable correction."*

And we have, more recently, the ingenuous confession of another geological naturalist to pretty much the same effect:—

"If, therefore," says Mr. Ansted, "in spite of the advantages of the pretty accurate mapping of Europe, and the detailed and minute knowledge of a positive kind which we possess geologically, there is still doubt and hesitation in determining the ancient history and the exact succession of deposits, it may well be supposed that not less, but much greater, difficulty exists with regard to other countries (India and China for example), of which we know far less."

And again

"Man may at some future day be able to comprehend this great plan of development (that of ancient animal existence); but he is not yet in that condition, and in his attempt to include its laws within the compass of his imagination, and express their true relation in language, he has hitherto always failed."†

"The convulsions and revolutions of the geological world," observes Mr. Miller, "like those of the political, are sad confounders of place and station, and bring into close fellowship the high and the

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* Manual of Geology, 2nd edition, Preface, pp. v. vi.
† Ancient World, 1847, pp. 329, 382.

low; nor is it safe in either world—such have been the effects of the disturbing agencies—to judge of ancient regulations by existing neighbourhoods, or of original situations by present places of occupancy. 'Misery,' says Shakspeare, 'makes strange bed-fellows.' The changes and convulsions of the geological world have made strange bed-fellows too. I have seen fossils of the upper lias and of the lower red sandstone washed together by the same wave out of what might be taken, upon a cursory survey, for the same bed, and then mingled with recent shells, algæ, branches of trees, and fragments of wrecks on the same sea beach."*

These evidences when taken at their full value, and considering by whom they are given, will go a great way to relieve us from any unnecessary anxiety as to the prejudicial influence which it might have been feared the affixation of a few names of *Reptilia* to the lists of organic remains of the several formations would have occasioned. For, by what has been said, it is evident that numberless accidents may have entombed the remains of reptiles very distinct in geological epoch; or, what is the same thing, much earlier in rocky stratification than their true epochs, when the places which they inhabited during their existence on the surface is duly taken into account.

With respect to the other division of this same difficulty—namely, the discovery of animal exuviæ in situations of which there can be no doubt as to geological correctness, although from the paucity of our knowledge of their individual conformation and habits there may be serious doubts as *to their having possessed the power of locomotion, in its proper signification*—it appears to us, that the strongest line of defence which we can take up is to express our firm conviction that no animal which encrusted the bottom of the ocean during its period of non-rotation was, or could be, possessed of the faculty of freely moving from place to place; that such ability was alike inconsistent with, and would have been prejudicial to, the development of the great plan of Creation, as we understand it to have been carried out. That locomotion, where all the surrounding

* Old Red Sandstone, 3rd edition, p. 156.

elements were alike, would have been a superfluous endowment, and, therefore, was not conferred; and finally, *without an atmosphere there could have been no voluntary motion impelled or sustained by aeriated blood.* With these declarations of our belief we leave this point to clear up itself when the great Scriptural announcements of the plan of Creation shall be better understood, more faithfully applied to the researches of philosophy and science, and more generally believed in. *Then*, we have no doubt, those seeming anomalies will give place to juster views, and more correct classifications; so that what now threatens to be a serious difficulty, will wholly disappear, and give place to a perfect, consistent, and convincing system of Cosmography.

We have now only to notice the remaining point in doubt, namely, the conflicting circumstance of the primitive waters being considered to have been fresh, while numberless remains of exuviæ correspond to living congenors inhabiting our present briny seas. In doing this, besides alluding to the minuteness of the difference of conformation which might enable a conchifer or mollusc to inhabit fresh water, we have to point out to our readers, *that the primitive ocean contained all the elements of its present saline nature, although differently combined*, and then to give the following conclusive extract from one of our most argumentative geologists, which seems to have been written so expressly for the occasion, although he was then treating of the origin of the Paris and Isle of Wight basins, that with it we shall close this part of our evidence:—

"The sources of the organic fossils," says Dr. McCulloch, "are no less obvious. But I must not pass from these without inquiring into their value in determining the *marine* or *other nature* of these strata. This is especially necessary, as the theory, and the mistakes of fact, together, have been among the chief sources of erroneous judgment in these cases, and will remain so as long as this engrossing pursuit shall occupy all the attention of geologists, and this hypothesis shall continue to rule. If to mistake respecting a fish has been sufficient to confound the class of Oeningen, it is easy to see what more may have happened and may happen again; not only in such instances, but in the judgment respecting alternating deposits.

"I do not give catalogues of species and genera. . . . . . I shall only, therefore, name among the living genera of fresh water *Lymneus*, *Planorbis*, *Physa*, *Paludina*, *Ampullaria*, *Cerithium*, *Melanopsis*, *Melania*, *Nerita*, *Cyclas*, and *Unio*. Of these *Lymneus*, *Planorbis*, *Physa*, *Paludina*, *Cerithium*, *Melanopsis*, *Melania*, and *Nerita*, are found in the fossil state; and *Paludina*, *Ampullaria*, *Cerithium*, *Melania*, and *Nerita*, are common to fresh and salt water. Of the shells called exclusively *marine*, *Modiolus*, *Mytilus*, and *Corbula*, live in fresh water; and different species of *Anodon*, *Cyclas*, *Unio*, *Tellina*, *Cardium*, and *Venus*, some belonging to fresh and others to salt water are found promiscuously in the Gulph of Livonia. Our own muscles and oysters, and many more, thrive better in fresh water than in salt; and reversely, many fresh water shell fish can live in salt water, and those of salt marshes are especially indifferent on this subject."*

* Geology, by Dr. M'Culloch, vol. i. p. 327, 328.

SECTION II.

THE ANIMAL EXISTENCES OF THE NON-ROTATORY PERIOD.

CHAPTER III.

Adaptation of the Apulmonic Invertebrate Animals to the state of the creation previous to the Earth's rotation around its axis. Origin of Calcareous Rocks, and the influential part which the primitive Animal Organisms performed in producing them. Increase of these rocks in an ascending series. Evidences for their existence deduced from geological writers. And a summary of the subjects treated of in this section, with an application of the whole to the progressive development of the Dynamical Theory.

Our information respecting the circumstances connected with animal life at the period to which allusion is now made having been brought to a point which enables us to proceed with the general argument; and having, to a certain extent, removed the obstacles which presented themselves to our progress, we shall endeavour, in the next place, to make apparent the perfect adaptation of the description of *animals* which we consider did exist to the then condition of our planet, on the supposition already assumed, *of its being unilluminated, without rotation, and enveloped by an atmosphereless ocean, differing in composition from what it does at present*, and, afterwards, adduce some of the more apparent reasons why animal life should at that period have been confined to beings of simpler conformation, and, comparatively, of sedentary habits. In developing this plan of procedure we shall commence by showing the nature and functions of *lungs* and *gills*.

"The aeriating organs of animals," says Dr. Fleming, "may be divided into two kinds, *lungs* (pulmones), and *gills* (bronchiæ), both

destined to accomplish the same end. The lungs are suited for bringing free air into contact with the blood, and therefore belong to those animals which have their residence on land. The gills are calculated to separate air from water, with which it is always united, and bring it into contact with the blood, and belong therefore to those animals which reside in the sea or in fresh water. It is to be observed, however, that many animals which reside in the water breathe by means of lungs, and are obliged, at intervals, to come to the surface to respire, such as whales; but there are no animals which reside on the land and are furnished with gills which are obliged to return to the water to respire.

"Whether the aerating organs be lungs or gills, it appears to be the object of nature in their construction to expose a large surface to the contact of the air. This object is accomplished by their division into numerous cells and leaf-like processes, or by their extension on the walls of cavities, or the surface of pectinated ridges. The blood brought to the organs by the pulmonic vessels is there distributed by their terminating branches. Although still retained in vessels, it can, nevertheless, be easily acted upon by the air on the exterior."*

After describing the accompaniments to those important organs, Dr. Fleming further observes:—

"In order to ascertain the changes which the blood undergoes when thus exposed to the influence of the air, it will be necessary to attend, in the first place, to the changes produced in the air itself . . . . . It is observed that the air which is alternately inspired and ejected becomes unfit for future use; and is likewise rendered incapable of supporting combustion. The analysis of this altered air indicates the change to have taken place in its oxygenous portion. A part thereof has disappeared, and an equal bulk of carbonic acid is found occupying its place. The quantity of oxygen in this carbonic acid is equal to that which has been abstracted from the air. In this case, either carbonic acid escapes from the blood and an equivalent bulk of oxygen is absorbed; or, the blood furnishes the carbon only, with which the oxygen of the air unites. The former supposition was long countenanced by chemists; the latter is at present the prevailing opinion."†

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* Philosophy of Zoology, vol. i. pp. 348, 349.

† Ibid, pp. 350, 351, and 137th Theorem.

"In respiration or breathing," says Mr. Hugo Reid, "the oxygen of the air is diminished one-third in quantity; and, either it is converted into carbonic acid by combining with carbon in the lungs; or, the oxygen of the air is absorbed and retained in the lungs, and carbonic acid is given off; or, both take place, so much oxygen being absorbed, and so much being given off in the state of carbonic acid. It is not certain which of these is the true theory of respiration, but it is certain that carbon (in union with oxygen) is expelled from the lungs during respiration. . . . . . And there seems reason to believe that the main use of respiration is to expel a superfluous quantity of carbon from the body, and that the oxygen of the air effects this by uniting with the carbon, and thus converting it into a gaseous substance (carbonic acid gas), in which form it is more easily got rid of."*

And thus is proved, in the words of the *hundred and thirty-eighth* Theorem "*that* ANIMAL RESPIRATION, *which consists in the alternate inhalation of a portion of air into the lungs, its transformation there, and subsequent exhalation, occasions, by means of the diffusion principle of gases, and of membraneous endosmose a reinvigorating interchange of gases. The oxygen of the atmosphere abstracting and occupying the place of the carbonic acid of the venous blood, which acid is exhaled in a gaseous form.*"

The next process to which we have occasion to direct the attention for a moment, is the formation of the shelly substance which constitutes the envelope, or, as it has by some been called, the external skeleton of the conchiferous molluscs, and other descriptions of marine animals.

Messrs. Todd and Bowman say—

"Among the invertebrated classes there are hard parts . . . . . which serve as bases of support for the soft parts. . . . . . The calcareous plates of the star-fish (*asterius*), and sea urchin (*echinus*), the hard coriacious covering of insects, the hard external integuments of crustacea, and the infinitely various shells of the gasteropoda and conchifera, must all be regarded in the light of hard parts performing the offices above referred to."†

* Lectures on Chemistry, pp. 61, 62.

† Physiology and Anatomy of Man, vol. i. p. 79.

Dr. Fleming asserts—

"That the most important appendix to the skin of the molluscous animals appears to be the *shell*. This part is easily preserved, exhibits fine forms and beautiful colours, and has long occupied the attention of conchologists. The matter of the shell is secreted by the *corium*, and the form which it assumes is regulated by the body of the animal. It is coeval with the existence of the animal, and appears previous to the exclusion from the egg; nor can it be dispensed with during the continuance of existence. The solid matter of the shell consists of carbonate of lime, united with a small portion of animal matter, resembling coagulated albumen.

"The mouth of the shell is extended by the application of fresh layers of the shelly matter to the margin, and its thickness is increased by a coating on the inner surface. These assertions are abundantly confirmed by the observations of Reaumer, whose accurate experiments have greatly contributed to the elucidation of conchology. If a hole be made in the shell of a snail, and a piece of skin be glued to the inner margin so as to cover the opening, the shelly matter will not ooze out from the broken margin of the fracture and cover the outside of the skin, but will form a coating on its inner surface; thus proving it to have exuded from the body of the animal. When a portion of the mouth of the shell of a snail is broken off, and a piece of skin glued to the inner margin, reflected outwardly, and fixed on the body of the shell, the defective part is again supplied, and the matter added to the inner surface of the skin, thus leaving the interposed substance between the new-formed portion and the fractured edge. Similar experiments, repeated on a variety of shells, both univalve and bivalve, by different naturalists leave no room to doubt that shells increase in size by the juxtaposition of shelly matter from the common integuments. . . . . . The layers of growth may often be distinguished on the surface of the shell, in the form of striæ or ridges, more or less elevated, but parallel to the margin of the aperture. . . . . . In some univalve shells, the layers of growth parrallel to the opening cannot be discerned. . . . . . By careful management, however, with the file, the shell may be separated into a central layer contiguous to the skin, and a peripheral layer, both similar in structure, though frequently differing in colour. The shells exhibiting such characters have been termed *Porcellanous*, from their dense structure and the fine polish which their structure presents. . . . . . The shells of the first kind which we have noticed, from being formed of cones or

layers applied to the inner edge of the margin, and extending beyond it, have an *imbricated* structure. Those of the second kind, consisting of layers regularly superimposed, have, consequently, a laminated structure; but between the two kinds there are numerous intermediate links, formed by a combination of the two processes."*

"The most simple form," says Professor Ansted, "in which an animal constructs a shelly habitation consisting of a number of compartments may be understood by examining any univalve shell. The greater part of the animal is inclosed in a muscular sac called a *mantle*, capable of depositing carbonate of lime.

"As soon as one coat is deposited, which, of course assumes the shape of the muscular mantle, the simple shell is perfected. If, as the animal grows, it is developed in a spiral form, the shell increases at the aperture; but if the extremity does not adapt itself to the original shell, and remains always of the same size, it must, as it increases, withdraw itself from its former compartment, and build a wall of partition, and in this way we have the first step towards the formation of the shell of the ammonite or nautilus, &c."†

Dr. Ure says—

"Marine shells may be divided, as Mr. Hatchett observes, into two kinds; those that have a porcellanous aspect with an enamelled surface, and, when broken, are often in a slight degree of a fibrous texture; and those that have generally, if not always, a strong epidermis, under which is the shell, principally or entirely composed of the substance called nacre, or mother-of-pearl.

"The porcellanous shells appear to consist of carbonate of lime, cemented by a very small portion of animal gluten. This animal gluten is more abundant in some, however, as in the patellæ.

"The mother-of-pearl shells are composed of the same substances. They differ, however, in their structure, which is lamellar, the gluten forming their membranes regularly alternating with strata of carbonate of lime. In these two the gluten is much more abundant."‡

"Testaceous shells," says Capt. T. Brown, "are composed of carbonate of lime, combined with a small portion of gelatinous matter; while those of the crustacea are composed of phosphate of lime, along with the animal matter. Testaceous shells are, in general, permanent coverings for the inhabitants, and the animal is

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* Philosophy of Zoology, vol. ii. pp. 401—404.

† Ancient World, pp. 243, 244. ‡ Chemical Dictionary, p. 741.

of a soft simple nature, without bones of any kind ; and attached to its domicile by a certain adhesive principle possessed by some of the muscles. . . . . . The shells of crustaceous animals are produced all at once ; those of the testacea evidently are formed by the animal gradually adding to them either annually or periodically."*

As we are at a loss to find any analyses of the composition, or an account of the manner of being formed, or of the specific gravity of the ponderous plates of massive scales which enveloped, as with coats of armour, the ancient fish-like forms which inhabited the primitive waters during certain of its epochs, we have been under the necessity of substituting inferential evidence, derived from the admirable descriptions given of them by recent writers. We shall endeavour to make these as concise as possible.

"Such," says Mr. Miller, when describing the *Pterichthys*, "at a first glance, is the appearance of the fossil. The body was of very considerable depth, perhaps little less deep proportionally from back to breast than that of the tortoise, the under part was flat, the upper rose towards the centre into a roof-like ridge, and both under and upper were covered with a strong armour of bony plates, which resembling more the plates of the tortoise than those of the crustacean, received their accessions of growth at the edges or sutures. . . . .

"Next to the *Pterichthys* I shall place its contemporary, the *Cocostens* of Agassiz. . . . . . Both were covered with an armour of thickly tuberculated bony plates, and both furnished with a vertebrated tail. The plates of the one, when found lying detached in the rock, can scarcely be distinguished from those of the other ; there are the same marks as in the plates of the tortoise, of accessions of growth at the edge—the same porous bony structure within, the same kind of tubercules without. The forms of the creatures themselves, however, were essentially different."

And further on, after referring to the trilobites *Asaphus Cundatus*, he proceeds—

"The fish and the crustacean are wonderfully alike. . . . . . . They illustrate admirably how two distinct orders may meet. They exhibit the points, if I may so speak, at which the plated fish is

* Conchologist's Text Book, p. 12, Theorem 157.

linked to the shelled crustacean." The *Cocostens* being a stage further towards a fish than the Cephalaspis.

"Of these ancient families the *Osteolepis*, or bony scale, may be regarded as illustrative of the general type. It was one of the first discovered of the Caithness fishes, and received its name, in the days of Cuvier, from the oseous character of its scales, ere it was ascertained that it had numerous contemporaries, and that to all and each of them the same description applied. . . . . .

"In their more striking characteristics the three genera, *Dipterus*, *Diplopterus*, and *Osteolepis*, seem to have nearly agreed. In all alike, scales of bone glisten with enamel; their jaws, enamel without and bone within, bristle thick with sharp pointed teeth; closely jointed plates, burnished like ancient helmets, cover their heads, and seem to have formed a kind of outer table to skulls externally of bone and internally of cartillage; their gill-covers consist each of a single piece, like the gill-covers of the sturgeon; their tails were chiefly formed on the lower side of their bodies; and the rays of their fins, enamelled like their plates and their scales, stand up over the connecting membrane, like the steel or brass in that peculiar armour of the middle ages whose multitudinous pieces of metal were fastened together on a ground-work of cloth or of leather.

"All their scales, plates, and rays present a similar style of ornament. The shining and polished enamel is mottled with thickly-set punctures, or rather punctulated markings; so that a scale or plate, when viewed through a microscope, reminds one of the cover of a saddle.

"In the *Glyptolepis* the most characteristic parts of the creature are the scales. They are of great size compared with the size of the animal. An individual not more than half-a-foot in length exhibits scales fully three-eighth parts of an inch in diameter. . . . . . Each scale consists of a double plate, an inner and an outer. The structure of the inner is not peculiar to the family or the formation: it is formed of a number of minute concentric circles, crossed by still minuter radiating lines. All scales that receive their accessions of growth equally at their edges, exhibit internally a corresponding character; and hence the name of the ichthyolite. The plates of the head were ornamented in a similar style. In all the remains of this curious fish which I have hitherto seen, the union of the osseous with the cartilaginous, in the general frame-work of the creature, is strikingly apparent. The external skull, the great shoulder-bone, and the rays of the fins, are all unequivocally osseous; the occipital

and shoulder-bones, in particular, seem of great strength and massiveness, and are invariably preserved, however imperfect the specimens in other respects; whereas, even in specimens the most complete, and which exhibit every scale and every ray, however minute, and shew unchanged the entire outline of the animal, not a fragment of the internal skeleton appears.

"The *Diplocanthus Longispinus* was first discovered by the writer about three years ago, and is a still more striking representative of this order than even the *Cheiracanthus*. The scales, minute, but considerably larger than those of the *Cheiracanthus*, are of a rhomboidal form, and so regularly striated—the striæ converging to a point at the posterior termination of each scale—that when examined with a glass, the body appears as if covered with scallops.

"The *Diplacanthus*, though the smallest ichthyolite of the formation yet known, is by no means the least curious. The scales, which are of such extreme minuteness that their peculiarities can be detected by only a powerful glass, resemble those of the *Cheiracanthus*; but the ridges are more waved, and seem, instead of running in nearly paralled lines, to converge towards the apex. The creature, unlike the *Cheiracanthus*, seems to have been furnished with jaws of bone: there are fragments of bone upon the head, tuberculated apparently on the outer surface; and minute cylinders of carbonate of lime running along all the larger bones, where we find them accidently laid open, show that they were formed on internal bases of cartilage.

"The *Osteolepis* was cased, I have said, from head to tail, in complete armour. The head had its plaited mail, the fins their male of parellel and jointed bars; the entire suit glittered with enamel; and every plate, bar, and scale, was dotted with microscopic points. Every ray had its double or treble punctulated group; the markings lie as thickly in proportion to the fields they cover, as the circular perforations in a lace veil; and the effect, viewed through the glass, is one of lightness and beauty. In the *Cheirolepis* an entirely different style obtains. The enamelled scales and plates glitter with minute ridges, that show like thorns in a December morning varnished with ice. Every ray of the fins presents its sculptured prominences, every scale its bunch of prickle-like ridges. A more rustic style characterized the *Glyptolepis*. The enamel of the scales and plates is less bright; the sculpturings are executed on a larger scale, and more rudely finished, &c."

And in conclusion from Mr. Miller on this particular branch of our subject :—

"Shall I venture," says he, "to throw out a suggestion on the subject in connexion with another suggestion which has emanated from one of the first of living geologists? Fish, of all existing creatures, seem the most capable of sustaining high degrees of heat, and are to be found in some of the hot springs of Continental Europe, where it is supposed scarce any other animal could live. Now, all the fish of the ancient type are thickly covered by a defensive armour of bone, arranged in plates, bars, or scales, or all the three modes together, as in the *Asteolepis*, and one-half of its contemporaries.

"The one-sided tail is united invariably to a strong cuirass ; and it has been suggested, by Dr. Buckland, that this strong cuirass may have formed a sort of defence against the injurious effects of a highly heated surrounding medium. The suggestion is, of course, based purely on hypothesis. It may be stated in direct connexion with it, however, that in the lias—the first richly fossiliferous formation overlying that in which the change occurred—we find, for the first time in the geological system, decided indications of a change of seasons.

"The foot-prints of winter are left impressed amid the lignites of the cromarty lias. In a specimen now before me, the alternations of summer heat and winter cold are as distinctly marked in the annual rings as in the pines or larches of our present forests; whereas, in the earlier lignites, contemporary with ichthyolites of the ancient type, either no annual rings appear, or the markings, if present, are both faint and unfrequent.

"*Just ere winter began to take its place among the seasons, the fish fitted for living in a highly heated medium disappeared:* they were created to inhabit a thermal ocean, and died away as it cooled down. Fish of a similar type may now inhabit the seas of Venus, or even of Jupiter, which from its enormous bulk, though greatly more distant from the sun than our earth, may still powerfully retain the internal heat."*

Carbonate of lime, according to the concurring testimony of all chemists, is composed of 43.6 of carbonic acid, and 56.4 of lime.†

* Old Red Sandstone, pp. 81, 85, 113, 114—116, 124—126, 131—133, 161.
† Dr. Ure's Chemical Dictionary, p. 245, &c.

"M. de la Beche," says Prof. Buckland, "has recently published a list of the specific gravity of living shells of different genera, from which he shows that their weight and strength are varied in accommodation to the habits and habitations of the animals by which they are respectively constructed. . . . . . The greatest observed density was that of a Helix, the smallest that of an Argonauta. The shell of the Ianthina, a floating, molluscous creature, is among the smallest densities. The specific gravity of all the land shells examined was greater than that of Carara marble; in general more approaching to Arragonite. The fresh water and marine shells, with the exception of the Argonauta, Nautilus, Ianthina, Lithodomus, Haliotus, and great radiated crystalline Teredo from the East Indies exceeded Carara marble in density. This marble and the Haliotus are of equal specific gravities."*

These expositions, therefore, show:—1st. That the principal end attained by pulmonic respiration is to throw off, through the medium of carbonic acid, a superfluous quantity of carbon from the circulating system. 2nd. That respiration by lungs necessarily implies the residence of the possessor in atmospheric air. 3rd. That the *conchifera*, *mollusca*, *cirripeda*, *zoophyta*, and *radiata* are not furnished with lungs, but with bronchiæ of an extremely rudimentary description, even in most of these classes; that they are principally situated *within* their shelly cavities, and are subject to the will of the animal. 4. That the *testacea* secrete their shelly coverings, by means of the *corium*, endogenously or by additional layers from within, to which they are continually adding. 5. That the heavy encasements of the ancient fish resembled more the testaceous coverings of molluscs than the pliant and buoyant scaly cuticles of recent fish; and were adapted rather for creatures inhabiting the profundity of an atmosphereless ocean, than to such as are dependent for life on atmospheric air, and must necssarily ascend occasionally to the aeriated strata of the sea, or altogether to its surface. And lastly. That the shells of *testaceous* tribes are principally composed of carbonate of lime, which, in turn, is a composition of carbonic acid and lime, in the proportions of 44 and 56 in 100 parts; while the

* De la Beche's Geological Researches, 1834, p. 76.

density, generally, of these shelly envelopes exceeds even that of Carara marble.

An intimate connexion seems thus evidently to subsist between the non-existence of an atmosphere, the want of lungs, and the formation and secretion (not the exhalation) of carbonic acid; for, had carbon been *required to have been ejected* through the medium of carbonic acid, lungs would not have been denied to the tribes which then inhabited the water; and if lungs, then a corresponding atmospheric medium. But so far from lungs and an atmosphere being then conducive to the plans of the Creator, we shall have occasion, presently, to confess, that they would have been positively inimical, and, therefore, they were withheld: for the great object *then desired was the formation of carbonate of lime.* And carbonate of lime was actually being accumulated by *the instrumentality of the internal functions of the testaceous tribes;* while it was, at the same time, being transformed into their beautiful, secure, and convenient envelopes; thus exhibiting the goodness, blended with the wisdom of God, for, that which yielded support, fixity, and defence against the pressure of the surrounding element to these ancient submerged animals, was also so disposed as *to yield carbonate of lime in a ratio equal to that which the periphery bears to the central bulk of any form whatever.*

We have only to extend our researches a little farther, to be convinced of the perfect adaptation of the means to the end, and of the harmony which prevailed between the state of animal life and of the earth at the period we allude to; for, it will be remembered, that carbonate of lime is composed of carbonic acid and lime. We have satisfactorily accounted for the source and application of the carbonic acid; to account for the lime, we must come to the unavoidable conclusion that its component elements were absorbed or extracted from a menstruum holding it in combination; for life, as we have seen, animating forms which were either altogether fixed, or possessed only of restricted power of motion, and surrounded by a tranquil medium, they had no other means of being supplied with the elements of lime than by the water in which they were immersed, while the tidal fluctuations of the

primitive ocean, occasioned by luni-solar influences, would be the means of bringing successive parts of the water within the reach of those which were absolutely fixed, and enable them to abstract those elementary principles necessary for the formation of carbonate of lime—an assumption corroborated by the fact *that whatever may be the diversity of their form, or their other constituent characteristics, carbonate of lime is invariably found to compose a great proportion of their fossilized remains.*

The operation alluded to, so essential for their own well-being; so admirably adapted for the great end in view—that of combining in them, and by means of their animal secretion, the requisite proportions of calcium with carbonic acid; perhaps we might even go farther, and say the formation by animal agency of *calcium* itself, and then effecting its union with carbonic acid—not only tended to abduct from the ancient ocean the primary elements necessary to effect those purposes, but by locking them up together, they became innocuous and insoluble, and capable of being preserved in that condition for the requirements of future beings. The water was drained of elements which, if left uncombined, would have been positively hurtful to future life; while, at the same time, the disturbance of the chemical equilibrium which was thereby effected, greatly tended, simultaneously, to promote the precipitation of other materials from the ocean holding them in combination.

We wish it particularly to be borne in mind, that the perfect adaptation of the species of animal life to the then condition, and to the progressive development of the earth's material crust, was one of the means which most effectually promoted and accelerated the whole operation.

By its being so planned, that the superflous, and consequently the otherwise injurious portion of carbon taken into the animal circulation should be got rid of, not by ejection, as now done through the medium of gills and lungs, and by combination with the oxygen of atmospheric air, but by internal secretion, and being by the agency of the corium formed into carbonic acid, and united with calcium into carbonate of lime, the sub-aqueous surface of the earth, wherever it was deemed requisite, became gradually enveloped by a calcareous crust

composed of the exuviæ of myriads of marine testacea, wonderfully destined, while enjoying the successive functions of their degree of animal life, to promote thereby the plans of the Creator. These slow, but unerring instruments in the work of calcareous elaboration, at the same time that they encoated themselves in their variegated shelly defences, unitedly encrusted that portion of the sub-oceanic surface to which many of them were affixed for life, and others nearly so, by the unalterable and wise decree of the Omnipotent. While they were thus destined and occupied, and well adapted by their species to the then condition of the surrounding creation, there appear to have been other concomitant objects wrought out by the agency of those animal elaborators. They were, as we have already so frequently asserted, and shall, by and by further insist upon, the only means which could be employed to disturb the chemical equilibrium of the water, and, thereby, to promote precipitation of other elements besides those required for their own outward defences. They were also producing and accumulating *molluscous animal matter*, of which one peculiar ingredient, after they had become extinct, assumed almost an etherial buoyancy, and ascended through the mass of waters to the very surface; nay, we might even venture to assert, throughout the whole of intervening space, to constitute the material bases of the etherial fluid, or of the primary light; there to await the further development of the great plan of Creation. All these ends, so essential to the object then in view, seem to have been intimately connected with partial or total *immovability* of construction; *fixation*, or degrees of fixation, could alone ensure the encrusting of the earth *where* such was necessary. The *profundity of the ocean* was the only locality where this could be done by a living agency; *Water* the only medium for holding the requisite component elements in suspension, in equality throughout, and in adaptation for being readily imparted in the quantities and proportions required by animal life successively developed; *Vacuum*, or the absence of the atmosphere, the most effectual means for the perfect retention of these accumulated exhalations, associated with the primitive waters; whilst on the part of its inhabitants fixation being so indispensable, movement

or fluctuation of the surrounding and containing fluid became as essential; hence the adaptation of the luni-solar current, which, even before the illumination of the sun, or the diurnal motion of the earth, must have been continually flowing round the non-rotating sphere.

Fortunately for the perfect establishment of the position which we have assumed, the presumptive evidence arising by contrast from the supposition of an opposite state of animal life during the period we allude to, when the several suits of strata were in progress of formation and enduration, is as conclusive in our favour. Animals endowed with locomotion (even could they have existed, which, before the atmosphere was formed, we consider impossible), would not have been adapted for the object designed. Had they been swift, free, swimming creatures, they must have been of nearly equal specific gravity with the element in which they moved; consequently, could not have been encased in a shelly coating of carbonate of lime weighing 2.7, or nearly three times the weight of the same bulk of water.* Deprived of this solid covering they would have left no calcareous exuviæ to promote the object for which the *testacea*, *zoophyta*, &c., were willed into existence. Had they been without this shelly defence against the pressure of an ocean, such a state would have been inconsistent with the goodness of God. On the other hand, had they been provided with ponderous testaceous coatings, and, at the same time, furnished with pulmonary organs befitting locomotion, and endowed with senses, organs, and perceptions of a higher grade of animal life, this condition, also, would have been at variance with our conceptions of the justice and benignity of the common Creator of the universe. For, how nugatory would have been the power of freely moving at will, whilst under such a load, without the requisite atmospheric air or light to have enabled them to use their faculties of motion!

Nor will the difficulties, under this suppositional view of the case, be in any degree lessened by supposing that many of the animals of the primitive ocean were akin to the *Cepha-*

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* Ure's Chemical Dictionary, p. 245.

lopoda, such as the ammonitic exuviæ have led some to suppose; for even in that case, they would have been dependent on atmospheric air to have assisted them in transporting freely from place to place their shelly abodes—a dependence which puts an end to the supposition of such a conformation, the atmosphere not having been then in existence. On the other hand, all these irreconcileable anomalies vanish when we assume the living creatures, which dwelt at the bottom of the primeval waters, to have consisted of those which are either incapable of locomotion, or only partially endowed with that faculty, and impelled by water. *Their* conformation and habits are in perfect accordance with the state of the world at that time, and with all its attendant circumstances. Light and darkness are equally the same to them. They are not dependent on atmospheric air. Their wants are amply supplied by the carrier water wherein they dwell; whilst, in the particular instance to which we allude, all that was going on *within* these zoophytic and testaceous creatures, *every atom of matter which they assimilated to their molluscous bodies, or to their zoophytic or testaceous coverings, was an atom added to and towards the promotion of the work then going on:* for ages every pulsation which took place in their imperfect circulating system along the whole underline of the dark and silent waters was a beat towards the accomplishment of the great plan of Creation! And, when that work was so far accomplished as afterwards to admit of its being completed, and when it pleased the Omnipotent to reveal to us the very words in which His commands were given for that purpose, we find no discrepancy even there, between what we have supposed and what actually took place: for, with an evident foreknowledge of their pre-existence, they were studiously and deliberately excluded from the Command which, on the fifth and sixth days of the Mosaic week, willed all the remaining tribes of animal beings into existence. True to the fiat of the Creator, "the *waters*" and "the *earth*" produced on those days "the moving creature that hath life; fowl that may fly in the open firmament of heaven; cattle, and creeping thing, and beast of the earth after his kind;" all of them being *animals possessing powers of free locomotion, dependent on atmospheric air and influences;* and which, in union with those previously

created "*in the beginning*" completed the animal kingdom, as it is now known to be.

As a summary of the whole of this part of our argument, and in addition to what we have been made aware of the effective adaptation of the particular description of animal life which has been assumed, for the furtherance of the work then required; and, while we firmly assert that the primeval atmosphereless waters were the abode of innumerable tribes of living creatures, we as firmly believe that not one of them could accelerate its own movements at will by means of aeriated blood; and, notwithstanding, that myriads of animals had, for ages, encrusted the bottom of the ocean, there was not, until the fifth and sixth days of the Mosaic week, a pair of perfect gills or lungs within the whole range of the solar system!

Although, after what has been so clearly and circumstantially stated, and considering the lists of organic remains which have been adduced, it is not very probable that any well-founded doubt can exist respecting the origin of the calcareous formations; or the important part which the exuviæ of marine animals have exercised in their construction; yet, to defend ourselves against the possibility of any such lurking suspicion in the mind, and to put the matter in the clearest possible point of view, we shall have recourse to part of the *sixteenth* Theorem, and to some of its innumerable authorities. The former asserts—*That with the exception of some of the inferior, the stratified rocks contain innumerable vestiges of vegetable, animal, and zoophytic remains. . . . . . Some of which are of gigantic dimensions in comparison with recent equivalents. . . . . . And that they have by their exuviæ contributed largely to the formation of the carboniferous and calcareous strata. The calcareous matter increasing in an ascending series, yet found to be, during every epoch, precisely similar in its component elements.*

It likewise forms a part of the *hundredth* Theorem, in regard to lime itself, *which is, by many, considered to be the product of animal secretion.*

In giving the evidences, we shall restrict ourselves to those having reference to *animal* remains. The fossilized vestiges

of *vegetation* will occupy our attention in their proper place. To proceed :—

"The origin of the limestones," says M. de la Beche, "is of far more difficult explanation than the sandstones and slates in which they are included. We cannot well seek it in the destruction of pre-existing calcareous rocks; for, as far as our knowledge extends, such rocks are of comparative rarity among the older strata. In fact, the quantity of calcareous matter present in the grauwacke group greatly exceeds that discovered in the older rocks; and the same remark applies to many of the newer deposits when considered with reference to the grauwacke series. If we take the mass of deposits, up to the chalk inclusive, we shall find that, instead of a decrease of carbonate of lime, such as we should expect if that contained in each deposit originated solely from the destruction of pre-existing limestones, the calcareous matter is more abundant in the upper than in the lower parts of the mass; and we may hence conclude that this explanation is insufficient.

"If, as has been done with other limestones, we attribute the origin of the grauwacke limestone in a great measure to the exuviæ of testaceous animals and polypifers, we must grant the animals carbonate of lime with which to construct their shells and solid habitations. This they may have obtained either in their food, or from the medium in which they existed. The marine vegetables are not likely to have supplied them with a greater abundance of carbonate of lime at that time than at present. Those that were carnivorous might acquire much carbonate of lime by devouring other animals more or less possessed of this substance; but the difficulty is by no means lessened by this explanation; for the creatures devoured must have procured the lime somewhere. It would appear that we should look to the medium in which testaceous animals and polypifers existed, for the greater proportion, if not all, of the carbonate of lime with which they constructed their shells and habitations. . . . . . This supposition would lead us to expect, that as the sea was gradually deprived of its carbonate of lime, limestone deposits would become less and less abundant; and, consequently, that calcareous rocks would be most common when circumstances were most favourable, that is to say, during the formation of the older rocks. This, however, is precisely the reverse of what has happened. Hence we may infer that the origin of the mass of limestone deposits must be sought otherwise than in the attrition or solution of older and stra-

tified rocks, or from the exuviæ of marine animals deriving their solid parts from a sea which has gradually been deprived of nearly all its carbonate of lime. . . . . .

"It has been usual to consider the lime of calcareous deposits as derived from limestone rocks, through which waters charged with carbonic acid percolated; the carbonic acid dissolving a certain portion of the lime, which is thus held in solution by the water until it reaches the surface, where it is thrown down in the shape of limestone.

"This explanation may suffice for the small deposits we observe in calcareous countries; but it is insufficient for the productions of limestones generally: for it assumes that the solution of a small quantity of lime obtained from older rocks is, as previously noticed, capable of producing an immense deposit of the same substance. . . . . . Lime has been derived somewhere; and we have reason to believe from the interior of the earth; otherwise there is a difficulty in explaining the observed phenomena. . . . . . It is also worthy of attention that when the limestones occur, then also do the organic remains generally become more abundant, appearing as if the calcareous rocks and the organic remains were connected with each other.

"That the animals, by secreting carbonate of lime from the medium in which they lived, somehow contributed considerably to the mass, we are certain, as their remains now constitute a large portion of it; but that they were the means through which all the carbonate of lime was derived from the waters may very justly be doubted; more particularly as in certain districts not a trace of animal exuviæ can be detected in such limestones.* If carbonate of lime were present in some situations and not in others, animals such as the *Crinoidea*, *Testacea*, and *Polypifers*, would naturally flourish more in the former than in the latter, as they could there more readily obtain the lime necessary for them; and we should, consequently, expect to find the remains more common there than elsewhere. In limestones devoid of organic remains we appear to have evidence of carbonate of lime being abundant in such situations unconnected with animal life; and we may consider it derived from the interior and dispersed through the waters over a given space, where it has

* The augmented powers of the microscope have done much since this paragraph was written to display the existence of animal remains where none was before suspected.—AUTHOR.

been gradually deposited. When, however, the remains of shells and corals are present, and nearly constitute the mass of the rock, other causes may have produced the effects required, precisely as coral reefs and accumulations of shells now occur in one place and not in another, either in consequence of shelter, proximity to the surface of the sea, or other favorable circumstances."*. . . . . .

And again M. de la Beche proceeds :—

"To discover that there may have been some connection between the animals with solid parts, and a facility of procuring carbonate of lime on the surface of the globe, appears perfectly consistent with the design manifested in the creation; because it asumes such design at all periods, and constant harmony between the forms of creatures and their mode of existence. If we imagine a mass of animals to be suddenly called into life, each properly provided with its solid parts, the carbonate of lime contained in these bodies would no doubt be sufficient for a constant quantity of the same animal during a succession of ages; for, by devouring each other, this necessary substance would be transmitted from one creature to another. We are, however, certain that this has not been the case; for the solid parts of animals which have been successively imbedded in various rocks, constitute a very large proportion of certain of those rocks, and, if withdrawn from the fossilliferous deposits generally, would very considerably diminish their thickness. Therefore, if the exuviæ of animals had not been entombed, and if the supply of carbonate of lime had not been greater than that which could have been derived from a mere destruction of one animal by another for the purpose of food, the surface of our planet would not have been what it now is; and, consequently, the fitness of things for the end proposed being constant in creation, the general condition of animal and vegetable life would not have been such as we now find it."†

The opinion of Dr. McCulloch respecting the origin of limestone formations is very interesting, as he has directed his attention closely to that branch of geological research; and, with much satisfaction, therefore, we have selected the following apposite passages from amongst innumerable others in his late publication:—

"The formation of coral islands proves that enormous and solid

* Manual of Geology, 2nd edition, pp. 450—452. † Ibid, p. 459.

masses of calcareous rock are the produce of animals alone; and when we reflect on the magnitude of some of these, we have no reason to be surprised at the extent of those rocks which, among the secondary strata, are composed chiefly of shells. Were we even to suppose that every particle of the largest bed of limestone known was originally part of a shell, we should, as far as the bulk of the mass is concerned, assume nothing that would be discountenanced by the magnitude of the great coral reef of New Holland. If the most minute animals of creation can thus by their numbers execute, unassisted, works of such enormous magnitude, and, as navigators think, within spaces of time comparatively limited, it is far from unreasonable to believe that the succession, through unnumbered ages, of animals so far exceeding these in bulk, and in the relative quantity of their calcareous produce, should have generated all the calcareous strata in the secondary series.

"It is not necessary here to ask whence the calcareous matter has been derived, or to suppose that it is an animal product. That difficulty is at present, unquestionably, insurmountable; but in this case it is of no moment. It can form no objection to the power of oysters or pectines in producing, by their own energies, a bed of limestone; because the fact, however inexplicable, is rendered unquestionable by the generation of coral from sea water. . . . . .

"Thus it may fairly be inferred, that while the siliceous and argillaceous secondary strata have been formed from the ruins of more ancient rocks, a large part, at least, of the calcareous is the produce of animals. Hence, also, it must appear, that from the operations of animals, the quantity of calcareous earth deposited in the form of mud or stone, is always increasing; and that, as the series far exceeds the primary in this respect, so a third series, should one hereafter arise from the depths of the sea, will exceed the last in the proportion of its calcareous strata. . . . . .

"The arenaceous and argillaceous rocks have been generated from the ruin of former ones, and the limestones are the produce of animals. . . . . . Considering that the degredation of land can never have ceased, I see no means of accounting for deep limestone masses, unmixed with arenaceous and argillaceous strata, except by considering these as the coral banks of a former earth; the present ones being the obvious types of the past, as they are the only limestone formations with which other strata cannot alternate. And that opinion is justified by the predominance of corals in these; while if they also contain shells, this is no more than occurs in the

present coral reefs. Co-relatively, where limestone beds alternate much with arenaceous and argillaceous strata, the conclusion must be, that these were formed chiefly by colonies or beds of shell fishes, while that opinion is also sufficiently borne out by the nature of the embedded fossils. . . . . .

"In applying this reasoning, therefore, to the lias of England, the obvious inference is, that after the deposition of the red marl, an increase of the organic creation became the source of the calcareous beds in this series; while being as yet but few, in comparison to what their power of propagation was hereafter to render them, the argillaceous and arenaceous deposits from the submarine land bore a larger proportion to them than in that subsequent condition in which the series of the oolite was formed. There is no mystery in these calcareous beds, or in this intermixture. The colony of animals, wherever existing, formed the limestone; it was a less rapidly populous one at its commencement than afterwards; and thence are the limestones more scanty below than above, compared to the other associated strata: while, when it was extirpated, from whatever causes, the deposition of the land, always proceeding, formed the intervening strata, separated into land and clay in the usual manner, until the re-establishment of a new colony enabled a new calcareous bed to be formed."*

The celebrated naturalist Lamark, in one of his works, affords also the following interesting evidence on this point:—

"The *meliolites* is a shell of most singular form, and perhaps one the most interesting to study, on account of its multiplicity in nature, and the influence which it has upon the condition and size of the masses at the surface of the earth, or which compose its external crust. It is one of those numerous examples which prove that, in producing living bodies, what nature seems to lose in size, she fully regains in the number of individuals, which she multiplies to infinity, and with a readiness almost miraculous. The bodies of these minute animals exert more influence on the condition of the masses composing the earth's surface, than those of the largest animals, such as elephants, hippotami, whales, &c., which, although constituting much larger individual masses, are infinitely less multiplied in nature. In the environs of Paris, some species of meliolites are so numerous,

* Geology, by Dr. McCulloch, vol. i. pp. 216—219, and vol. ii. pp. 256, 257, 261, 262

that they form almost the principal part of the stony masses of certain ranges."

Mr. Lyell says—

"No shells are more usually perfect than the microscopic, which abound near Sienna, where more than a thousand full-grown individuals are sometimes poured out of the interior of a single univalve of moderate dimensions."

Again—

"The *testacea*, of which so great a variety of species occur in the sea, are a class of animals of peculiar importance to the geologist, because their remains are found in strata of all ages, and generally in a higher state of preservation than those of other organic beings. Climate has a decided influence on the geographical distribution of species in this class; but as there is much greater uniformity of the temperature in the waters of the ocean than in the atmosphere which invests the land, the diffusion of many marine molluscs is extensive."

He further states—

"A modern writer has attempted to revive the theory of some of the earlier geologists, that all limestones have originated in organised substances. 'If we examine,' he says, 'the quantity of limestone in the primary strata, it will be found to bear a much smaller proportion to the siliceous and argillaceous rocks than the secondary, and this may have some connection with the rarity of testaceous animals in the ancient ocean.' He further infers that in consequence of the operations of animals, 'the quantity of calcareous earth deposited in the form of mud or stone is always increasing; and that as the secondary series far exceeds the primary in this respect, so a third series may hereafter arise from the depths of the sea, which may exceed the last in the proportion of its calcareous strata.'

"If these propositions went no farther than to suggest that every particle of lime that now enters into the crust of the globe, may possibly in its turn have been subservient to the purposes of life by entering into the composition of organized bodies, we should not deem the speculation improbable; but when it is hinted that lime may be an animal product combined by the powers of vitality from some simple elements, we can discover no sufficient grounds for such an hypothesis, and many facts which militate against it." . . . .

In conclusion Mr. Lyell says—

"So wonderfully minute are the separate parts of which some of the most massive geological monuments are made up! When we desire to classify, it is necessary to contemplate entire groups of strata in the aggregate; but if we wish to understand the mode of their formation, and to explain their origin, we must think only of the minute subdivisions of which each mass is composed. We must bear in mind how many thin, leaf-like seams of matter, each containing the remains of myriads of testacea and plants, frequently enter into the composition of a single stratum, and how great a succession of these strata unite to form a single group! We must remember, also, that volcanoes like the Plombdu Cantal, which rises in the immediate neighbourhood of Aurillac, are equally the result of successive accumulation, consisting of reiterated flows of lava and showers of scoriæ; and we have shown, when we treated of the high antiquity of Etna, how many distinct lava-currents, and heaps of ejected substances are required to make up one of the numerous conical envelopes whereof a volcano is composed. Lastly, we must not forget that continents and mountain chains, colossal as are their dimensions, are nothing more than an assemblage of many such igneous and aqueous groups, formed also in succession during an indefinite lapse of ages, and superimposed upon each other."*

Mr. Miller, in his usual graphic style, affords the following evidence:†—

"Of late," says he, "the geologist has learned from Murchison to distinguish the rocks of these two great geological periods—the lower as those of the Cambrian, the upper as those of the Silurian group. The lower—representative of the first glimmering twilight of being—of a dawn so feeble that it may seem doubtful whether, in reality, the gloom had lightened—must still be regarded as a period of uncertainty. Its ripple-marked sandstones, and its half-coherent accumulations of dark coloured strata, which decompose into mud, show that every one of its many planes must have formed in succession an upper surface of the bottom of the sea. . . . . . In one locality it would seem as if a few worms had crawled to the surface,

* Principles of Geology, vol. ii. pp. 307—310. vol. iii. pp. 47, 163, 239, 240.

† In order to adapt this passage to our work, and the object we have in view, we have very reluctantly been obliged to abstract it more than we otherwise should have wished.—Author.

and left their involved and tortuous folds doubtfully impressed on the stone. . . . . . . But even these worms of the Cambrian system can scarcely be regarded as established. . . . . . There is less doubt, however, regarding the existence of the upper group of rocks—the Silurian.

"The depth of this group, as estimated by Mr. Murchison, is equal to double the height of our highest Scottish mountains. And four distinct platforms of beings range in it, the one over the other, like storeys in a building. Life abounds in all these platforms, and in shapes the most wonderful: the peculiar encrinites of the group rose in miniature forests, and spread forth their sentient petals by millions and tens of millions amid the waters; vast ridges of corals, peopled by their innumerable builders—numbers without number—rose high amid the shallows; the chambered shells had become abundant—the simpler testaceæ more so; extinct forms of the graptolite or sea-pen existed by myriads; and the formation had a class of creatures in advance of the many-legged annelids of the other. It had its numerous family of trilobites—crustaceans nearly as high in the scale as the common crab—creatures with crescent-shaped heads, and jointed bodies, and wonderfully constructed eyes, which, like the eyes of the bee and the butterfly, had the cornea cut into facets resembling those of the multiplying glass. . . . . .

"The locomotive powers of the trilobite seem to have been little superior to those of the chiton (which in many other respects it very much resembled). If furnished with legs at all, it must have been with soft rudimentary membranaceous legs, little fitted for walking with; and it seems quite as probable, from the peculiarly shaped under margin of its shell, formed like that of the chiton for adhering to flat surfaces, that, like the slug and the snail, it was unfurnished with legs of any kind and crept on the abdomen. . . . . . .

"Another and superior order of existences had sprung into being at the fiat of the Creator—creatures with the brain lodged in the head and the spinal cord enclosed in a vertebrated column. In the period of the upper Silurian, fish properly so called, and of very perfect organization, had become denizens of the watery element, and had taken precedence of the crustacean, as, at a period long previous, the crustacean had taken precedence of the annelid. . . .

"The fish bed of the upper Ludlow Rock abounds more in osseous remains than an ancient burying-ground. The stratum, over a wide area, seems an almost continuous layer of matted bones, jaws, teeth, spines, scales, palatial plates, and shagreen-like prickles, all massed

together, and converted into a substance of so deep and shining a jet colour, that the bed, when 'first discovered, conveyed the impression,' says Mr. Murchison, 'that it enclosed a triturated heap of black beetles.' And such are the remains of what seem to have been the first existing vertebrata.

"Thus ere our history begins, the existence of two great systems, the Cambrian and the Silurian, had passed into extinction, with the exception of what seem a few connecting links, exclusively molluscs, that are found in England to pass from the higher beds of the Ludlow Rocks into the lower or Tilestone beds of the old Red Sandstone."*

"The exuviæ of at least four platforms of being lay entombed, furlong below furlong, amid the grey mouldering mud stones, the harder arenaceous beds, the consolidated clays, and the concretionary limestones, that underlay the ancient ocean of the Lower Old Red. The earth had already become a vast sepulchre, to a depth beneath the bed of the sea equal to at least twice the heighth of Ben Nevis over its surface."†

These extracts from the writings of geologists who have given the subject their careful attention, both *in situ*, in the field of labour, as well as in the retirement of their closets, cannot fail to be otherwise than conclusive and convincing to every one *of the paramount influence which the fossil exuviæ of marine animals have exercised in the formation of calcareous strata.*

The derivation of the elements which enter into the composition of the carbonate of lime, of which those remains consist; or whether this, or even calcium itself, be or be not the product of animal vitality and secretion, do not affect the main question so long as it is unanimously admitted by all *that the greater proportion of the calcareous and calcareo-argillaceous deposits are composed of the fossilized remains of what once were living creatures.*

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* Note by Mr. Miller. "Upwards of eight hundred extinct species of animals have been discribed as belonging to the earliest, or Potozoic and Silurian period, and of these only about one hundred are found in the overlying Devonian period, while but fifteen are common to the whole palæozoic period, and not one extends beyond it." *M. de Verneuil* and *Count D'Archiac* quoted by Mr. D. T. Ansted, 1844.)

† Old Red Sandstone, 3rd edition, pp. 266—272.

We could, were it in any way conducive to the scope of our general argument, bring forward numerous evidences in favour of opposing hypotheses regarding the source of the calcareous material of which these rocks are composed. We might find men, apparently equally competent to judge, bringing forward facts and instituting arguments to prove assumptions quite incompatible with each other; but as most of those investigations—interesting for the research they display, and the facts they abound with, adduced from personal experience—are based upon, and have reference to causes now in operation, they do not affect our general subject any further than by shewing, that animal agency is still requisite to preserve "the Seas" in that normal state of purity to which the primeval waters were brought, before the Creator considered them fit to be separated from the "dry land."

The evidence which conclusively proves that tuffa and calcareous marl are accumulated only in those lakes and other receptacles of water into which springs flow, which percolate through the surrounding formations, supposed to consist of similar material, may, with equal effect, be employed to demonstrate the expediency, nay, the necessity of polypifers and conchiferous molluscs being made instrumental, on a more extensive scale, in freeing the wide tropical oceans of that superabundance of lime which their heated waters cannot sustain: for the well-established, though anomalous fact in chemistry, that water, when warm, dissolves less lime than when cold* should not be overlooked in any hypothesis connected with this subject, and especially in any attempt to account for the increase of calcareous deposits in proportion as they approach the exterior of the Earth's outer crust. To this—to the material increase of numbers which marine animals, when unmolested, undergo by propagation—and to the immense mass of limestone debris which, in common with that of other rocks, would be spread abroad by the centrifugal impetus of the first rotation, we feel disposed to attribute the greater abundance and more general prevalence of calcareous matter, according as the formations are more recent.

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* The hundredth Theorem.

The admission which thus seems so irresistible—that the primitive waters contained the elements, and that apulmonic animal life became, by secretion, the active agency by which those elements were gradually abstracted from the surrounding medium, accords so admirably with the conception of the reciprocal influence of the liquid upon the solid portions of the globe—the one contributing towards the formation of the other, and the perfecting of both being the result of their mutual progress—that we cannot, if we would, separate them from each other in our imagination. We cannot conceive otherwise than that the deposition from the primitive menstruum was as indispensable towards the purification of the waters, and to prepare them for becoming "*the seas*" of the present day, as that the rocky material was requisite for the completion of the solid strata which was being formed beneath. It was, in fact, the same operation. What the primitive ocean resigned to render it the sea, the mineral bed beneath acquired to solidify it into a rocky stratum; whenever the interchange became sluggish, by the aqueous medium assuming a static condition of equilibrium, to which chemical compounds in large masses are ever prone, fresh excitement was given to the work of progression by the creation of a more searching and influential race of animal existences. The equilibrium by this means became disturbed, and the abstraction and solidification again went on. That this is in strict consistency with the opinions generally entertained at the present day, we must be allowed to insist upon. No one for a moment doubts that the stratified masses underwent a protracted course of progressive preparation to fit *them* for the important part which *they* had to perform in the economy of the earth's formation; and we can, therefore, recognise no just cause to deny to the less consistent oceanic waters, which also were from "the beginning," the necessity of undergoing some analogous process of preparation to enable them also to perform *their* part in the newer economy, when the earth should be no longer slumbering without rotatory motion, and bearing them tranquilly over all its surface; but when they should be confined within narrower troughs of much greater profundity, and be the limpid, sparkling seas of our present day.

We can conceive no other condition of the primitive waters and of the earth before their present states were conferred upon each of them, but if any one else can, let him come forward and clearly demonstrate it. Meanwhile, in corroboration of our opinion, we shall, without adducing any of the evidences, recapitulate the words of the *ninety-seventh* Theorem.

That geologists generally concur in the opinion, that the sea is the residium of a primitive ocean, which, at one time or other, seems to have covered the dry land which now constitutes the habitable surface of the globe. That from it were deposited the mineral ingredients which compose the inorganic portion of the stratiform masses of the earth. That this separation simultaneously prepared the primitive ocean for becoming the present sea. And, lastly, it has been maintained, especially by some of the earlier geologists, "That there are no operations now taking place in the sea, which bear the slightest analogy to those productions of mineral substances in strata which took place formerly on our globe."

We have only now to take into consideration the circumstance of the calcareous formations increasing in an ascending series from the grauwacke to the chalk inclusive, and to compare this with the analogy of the natural increase of apulmonic animal life, in order to be convinced that there exists an intimate connexion between them.

The horizontality of surface of the primitive earth, assumed to be a perfect sphere surrounded everywhere by an equal depth of water,* entirely precludes any recourse being had to the supposed influence—during the non-rotatory period—of springs, volcanoes, fissures, or disintegration. To be consistent we must discard them from all arguments having reference to that period and condition of our globe; however much we may be disposed to admit the influential part they perform at present, and under entirely different circumstances, in supplying our seas, lakes, and rivers with the calcareous material required by their present inhabitants to fabricate their shelly

* The surface of a sphere whose diameter is 8,000 miles, may, for all practical purposes, be considered *level*. When we say "an equal depth of water," we do so irrespective of the luni-solar wave which travelled round the non-rotatoring earth.

and beautifully diversified coverings. In the former economy we must alone look to the important uses which were made of apulmonic animal life, testaceous and zoophytic, for the proper explanation of the phenomenon in question. Deposition from the primeval ocean, chemically charged with numerous ingredients possessing different degrees of affinity for each other, was a principal object sought; but, in a chemical compound of inert matter, when once the affinities of the several ingredients are satisfied or completed (and to this state, after every partial disturbance—whether this be effected by the abstraction of some materials, or the addition of others—compounds are ever prone to recur), the static condition of the equilibrium they assume, cannot, of themselves, be altered, for "matter can neither generate motion nor change in itself, nor alter the direction or the velocity of that which may be impressed upon it;" and we must, therefore, of necessity, look to some other sufficient cause—a cause independent of the medium itself—for the disturbance of the equilibrium, and the acceleration of the deposition of the material held in solution. It appears, from the concurring evidence of all geologists, that the formation of calcareous matter went on increasing in an ascending series, and we should, therefore, look for a power which also went on augmenting. An inert precipitate, falling from a mass where chemical affinity was tending thereby to produce an equilibrium amongst its ingredients, would have gradually declined in energy.

A local living agency, radiating from foci of creation, reproducing themselves with that rapidity which comparative security from the rapacity of other creatures permits; coating themselves with carbonate of lime, as we see them now do, whose component elements they abstracted from the surrounding medium; and, by these increments of abstraction, occasioning a simultaneous deposition of other ingredients from the primitive ocean, seem to fulfil all the conditions of the problem, and to leave no desideratum unsatisfied; so that we can hardly acknowledge the necessity of seeking for any cause beyond the agency of the testaceous and zoophytic animals with which, as we have so clearly demonstrated, the submarine surface of the earth was densely encrusted; and more especially so, as

this, which forces itself so strongly upon our notice, may be considered competent to have produced the effect. This conviction will be materially strengthened when we come to adduce the analogous fact, placed on clear, undeniable record, that the waters were commanded, and immediately did produce the more recent congenors of those testaceæ and zoophyta. For, upon the presumed principle *that no secondary agent of the Creator was ever called upon to perform any part of the great work of creation without having the necessary materials placed at its disposal*, we are led, by analogy, to conclude, in corroboration of our previous position, that the primitive waters of our sphere, before rotation was impressed on it, did contain those elements which, by the enduring, tranquil agency of the more simple forms of marine animal life, produced those vast and pervading calcareous coatings of the earth's mineral crust which, unless we knew the effects of persevering industry, we might be apt to consider entirely disproportionate to their puny powers.

The consideration of these wonderful facts, however, and of the well-authenticated circumstance of the prevalence at the bottom of the ancient ocean of innumerable living forms, which we know, from their exuviæ, did encrust themselves with carbonate of lime, will, when taken in combination, strengthen our belief as to the importance of the labour which they performed, and the danger of either undervaluing it, or of ascribing it to other origin; otherwise we shall not only overlook a very important and influential secondary cause, but omit to attribute to that cause a commensurate effect. In a subsequent part of this treatise we shall have occasion to show, in continuation of what has already been stated, that, in addition to the work assigned to these successive races and forms of apulmonic creatures—of encrusting the shell of the earth with carbonate of lime at the bottom of the primitive ocean—they were destined, all the while, by the wisdom of the Creator, to produce a peculiar animal secretion, required for the formation of the life-sustaining atmosphere, and designed to be associated in it with another, without which no air-breathing animal could, for one moment, have existed.

And that, however wonderful this arrangement may seem,

it is equalled only by the wise forethought which devised that this subtile and buoyant element should, in its primary form, have been produced and set free at the bottom of the ocean; its ascent, as it percolated in this state through the superincumbent waters, contributing very essentially to the work of precipitation which was then going forward throughout their whole expanse.

We trust it may not be out of place to endeavour, here, to generalize the evidence which we have gone through in detail as far as it bears upon the necessity—if we may be allowed so to express ourselves—for there having been a *succession of sub-marine animal life,* to ensure the success of the co-relative operation during the protracted process of encrustation with calcareous material and the purification of the waters.

The fact that the primitive earth was enveloped by a menstruum which, *ab initio,* contained the calcareous elements in chemical combination, when contrasted with that of the ratio of encrustation having kept pace with the increasing power of the water to retain these elements in its grasp, *necessarily implies a change in the inermediate living and operative agency.*

As the work *beneath* went on increasing, just in proportion as the reluctance to part with the means went on augmenting *above,* from whence alone the necessary supply could be obtained, there appears to have been no other method, consistent with the laws prescribed for the creation, of bringing about the double effect then contemplated, short of a change in the agency, and an increase of its power of abstraction and assimilation; an increase of warmth in the containing medium being added as an essential auxiliary. While it ought to be borne in mind, as an additional reason for coming to this conclusion, that as the waters were undergoing a gradual change, as from Z to A, while the earth, benefitting thereby, was simultaneously altering its state, as from A to Z, the *same* living agency could not, during the whole intervening period, have effected the interchange which was necessary between the two mutating bodies.

In conclusion of this part of our discourse we have to express our hope of having, in the first place, shown the close

analogy which existed, during the primeval era, between the forms, the nature, and the functions of the living creatures which then encrusted its submerged surface, with the absence of light and of an atmosphere; and not only this, but also the object had in view, by their priority of existence; inasmuch as they appear to have been the instrumentality made use of to elaborate part of *the material bases* of which the light and the atmosphere are composed.

The precise wording of Scripture leaving no doubt on our minds, that whereas "in the beginning God created the heaven and the earth," so *thereafter*, nothing material was created; and, consequently, as the etherial fluid, however closely bordering on immaterialism is yet matter, it must, during the period of non-rotation, have, likewise, been created.

And, finally, we consider that by the exposition which we have given, we have established, as far as the state of information on the subject will permit, the position we assumed at the commencement of this section—namely, *That before the rotation of the earth around its axis, or during the period called in Scripture "the beginning," the primitive, dark, and atmosphereless waters were the abode of innumerable races of living apulmonic creatures, independent alike of light or atmospheric air for life or motion. The greater part consisting of descriptions which either were entirely fixed, or moved but imperfectly;* and *that of these there were several successive generations.* And, having done this, we have wrought out, as far as this particular branch of evidence is available for that purpose, the proof we have to afford. *That during the same Scriptural period of indefinite duration, there was formed and forming, by the united instrumentality of animal and vegetable secretion and decomposition, of crystallization, and of ordinary deposition, the materials which were afterwards to constitute all the geological and meteorological phenomena; when they should, by the centrifugal impetus engendered by the protorotation of the earth, be placed in their respective positions. And that, by the same instrumentality, the primitive waters were, likewise, undergoing due preparation for*

their present condition. And in effecting this we have manifested the dependence which philosophy ought to have on Scripture, *our position being as consistent with the true meaning of the inspired narrative, given in Genesis, as it is accordant with the results of philosophical investigation, and of geological research.*

SECTION III.

THE VEGETABLE ORGANISMS OF THE NON-ROTATORY PERIOD.

CHAPTER IV.

The subject of argument of this Section stated. The Vegetation of the Non-rotatory period neither flowering nor seed-bearing plants. Striking analogy in this respect to the Apulmonic Creatures which were the subject of the previous Section, pointing to a common cause; and, therefore, requiring to be treated in a similar manner. The Dicotyledonous class of plants fully described. The Monocotyledonous also minutely characterized, and both of these great divisions eliminated from the argument, as having been formed during the Mosaic week. These, however, not comprising the entire Vegetable Kingdom, leave the Acotyledons as a residue, which are considered to have been willed into existence during the period of non-rotation This latter class closely delineated, and their functions particularized.

In following out the plan which has been laid down for the consideration of our subject, the attention must now, for a short time, be directed to an interesting group of natural objects, which contributed very materially to the formation of the stratified masses, as well by constituting, in themselves, the greater portion of the coal-measures, as by the influence which they exercised over the imperfect animal life then in existence; and also by occasioning depositions from the surrounding primeval fluid. We allude to the Flora of the ancient world, as represented by the Fossil Vegetable Remains found embedded in the strata.

It may be as well to understand, that we proceed upon the supposition that, during the protracted period when they existed and grew in succession, the circumstances of our planet

were identical with those premised when treating of the apulmonic animal kingdom, namely—*That it was an unillumined sphere, without rotatory motion, and circumbounded by an atmosphereless ocean of considerable depth; higher in temperature, and differing considerably in the combination of its associated elements when compared with the present seas.*

The point then to be established is—*That although in the primeval ocean there grew innumerable plants, of which there were several successive creations, yet they did not belong to any class possessing true seeds, or fruits having seeds within themselves, requiring dry land and atmospheric air for their full development and the performance of their several functions.*

This branch of our enquiry is involved in still greater difficulties than the previous one, from the fact that there is not, as in the case of the animal creation, so broadly a marked line of distinction drawn between those objects of the vegetable kingdom which were created at the beginning, or during the period of non-rotation, and those willed into existence on the third day of the Mosaic week. We would beg, however, to be understood as implying by this observation, not that the indistinctness of the line of demarcation is attributable to the Creator, to whom the essential difference is clearly known, but to the imperfect intelligence of man in classing those objects into groups even in their recent condition, and much more so in their fossil state; especially when the objects of research approach the boundaries of the lower denominations of plants, in which the absence of flowering and seeding processes and other essential distinctives often leave the investigator at a loss; while the difference between aquatic and terrestrial plants is very indistinctly observed; or rather, not observed at all; as a proof of which the former is associated in the great *class Cryptogamia*, as one of its *orders.*

Despite, however, of these difficulties, we trust, successfully to shew that the great mass of fossil plants found in the strata were distinct in their nature and characters from those willed into existence by the command, narrated in the 11th and 12th verses of the 1st chapter of Genesis, in the concise yet comprehensive words: "And God said, Let the earth bring forth

grass, the herb yielding seed, and the fruit tree yielding fruit after his kind, whose seed is in itself upon the earth: and it was so. And the earth brought forth grass, and herb yielding seed after his kind, and the tree yielding fruit, whose seed was in itself after his kind: and God saw that it was good."

It is when looking at the subject in the point of view in which we have placed it, that a striking analogy is recognized—a strong mannerism, if we may be allowed so to express ourselves—in the primitive works of creation. There was no atmosphere; and, accordant therewith, the animals were apulmonic, and, consequently, deficient in their power of locomotion. The *plants* had neither flowers, seeds, nor fruits, but rudimentary sporules, possessing neither radicle nor plumule, and, consequently, alike insensible to light or darkness; while none of their processes seemed to have required dehiscence, which can alone be brought into operation by atmospheric air. As there had been a succession of animal life, adapted to the several stages through which the primitive formations passed, and as the change in the condition of the primitive waters demanded; so, in like manner, there appears to have been a series of changes in the then vegetable kingdom, corresponding to the changes in the condition of our planet. And, lastly, the description of plants discovered in the strata have a close analogy to recent plants of *imperfect formation*, or those denuded of floral and fructifying, or seeding processes, properly so called; or, in other words, they correspond to those which, under the conceptions formed, might, *a priori*, have been expected to have been found there. Besides, when we come to apply the result of our previous investigations, we shall find strong presumptive evidence for concluding that all the plants of the primeval era were aquatic. The primitive animals were inhabitants of the water; their remains are found *wherever* geologists have investigated; consequently, the whole globe must, at one time or other, have been under water; and we have no authority for supposing one condition of the earth for the *Animal*, and, at the same period, a different condition for the *Vegetable* kingdom. The proof which goes to show that the earth was circumbounded by oceanic waters in the one case, cannot, as their geological eras were identical, be set

aside, or weakened in the other. But, that all may be able to form their opinions on more circumstantial data, we shall go on to examine the evidences leading to this conclusion, in doing which, as it will greatly contribute to perspicuity and conviction to adopt such a plan of investigation as shall dispose simultaneously of whole groups of plants, we shall do so accordingly.

Pursuing this method, we shall commence by acquiring a knowledge of the CLASSES which compose the whole vegetable kingdom, according to the natural system of botany; together with the various *orders*, *genera*, &c., of those classes which it may be essential to particularize. For this purpose we refer to the concluding words of the *hundred and thirteenth* Theorem; and proceed to give the evidences upon which they are founded.

Professor Henslow says—

"With very few exceptions, nearly all plants may be referred by any botanist at a single glance, and with unerring certainty, to their proper classes; and a mere fragment, even of the stem, leaf, or some other part is often quite sufficient to enable him to decide this question. The names of these three classes are derived from one of the chief characteristics which prevails through *nearly* all the species included under each of them separately. This we shall presently explain; but the reader may understand these names to be DICOTYLEDONS, MONOCOTYLEDONS, and ACOTYLEDONS; and that the two former of these classes have, respectively, the names of *Exogenæ*, and *Endogenæ*. The former being derived from peculiarities connected with the structure of the seed; the latter from a consideration of the internal organization of the plants themselves. . . . . .

"In the very slight sketch here given of the primary groups under which all plants may be arranged, we have not pretended to notice any terms which different botanists have applied to them; but we shall now collect the substance of what has been said in the form of a table to assist the memory of the reader.

	EMBRYO.	STRUCTURE.	FRUCTIFICATION.
1.	Dicotyledons	Exogenæ	Phenerogamæ
2.	Monocotyledons	Endogenæ	
3. 4.	Acotyledons	Ductulosæ	Cryptogamiæ."*
		Cellulares	

* Botany, by Professor Henslow, pp. 30, 37.

The author of the article on Botany, in the Library of Useful Knowledge, when treating of the natural grouping of plants, expresses himself thus:—

"In their internal structure stems are apparently constructed upon several different plans; in the bamboo they are hollow, with transverse partitions; in the cane they are solid, and of an uniform density; in the oak they are hardest in the centre; in the cocoa-nut they are softest in the centre; in many climbers they have an uniform density, and appear pierced with multitudes of cylindrical channels parallel with the bark. In ferns the wood has a singularly twisted appearance; and finally, in many herbaceous plants it seems to consist of a mass of succulent substance, with a few fibres mixed among it. But it has been ascertained that all these variations are to be reduced to three primary forms, viz., EXOGENS, or those which have their woody system separated from the cellular and arranged in concentric zones; ENDOGENS, in which the woody and cellular systems are mixed together into a confused mass; and ACROGENS, which consist of a cylinder growing at its point only, and never augmenting in thickness after it once is formed."*

The following table, presenting a comprehensive view of the classification of plants, is taken from Baron Cuvier's work:—

"The VEGETABLE KINGDOM containing living beings with roots, without sensation, or voluntary motion:—

DIVISIONS.	CLASSES.
1. A-COTYLEDONS. Agamons, or rather cryptogamous plants, without stamens or pistils	1. Aphyllæ 2. Folliaceæ
2. MONO-COTYLEDONS. Plants, having the embryo with only one cotyledon, perianth simple, consisting of a calyx only; floral organs, generally three, or multiples of three; nerves of the leaves generally longitudinal; stem composed of cellular tissue, with scattered vascular fascionti.	1. Hypogynia 2. Perigynia 3. Epigynia

* Library of Useful Knowledge, p. 14.

3. Di-Cotyledons. Plants, having their embryo with two cotyledons, excepting the coniferæ, where are often from three to ten verticillate cotyledons; all of the parts of the stem disposed in concentric layers; flowers generally with a calyx and corolla, the parts of which are usually five, or some multiple of five; nerves of the leaves generally ramified.	1. Monochlamydeæ 2. Dichlamydeæ. *a* Corollifloræ *b* Calcyfloræ *c* Thalamifloræ.*

The author of the *Sacred History* gives the following explanation of the motives of the divisions which exist in the *Natural System* of Botany:—

" The seed contains the embryo plant in the little corculum, which all, on being carefully opened, display. It is familiarly called the heart of the walnut, the little figure at the one end of all nuts and kernels. Vessels extend from this to the substance in which it lies, which has received the name of cotyledon. If this be single, as in the grasses and corn, it is Monocotyledonous; if, as in the larger herbs and trees, it consists of two lobes, they are called Dicotyledons; and, if no such are discernable at all, they are termed Acotyledonous plants, which in some, and, perhaps, in most countries are the most numerous."

These quotations will be sufficient to convince any one that all known plants—and the number known and classed, recent and fossil, is very great—may either be referred to, or distinguished by comparison with some one of the *three classes* enumerated. In order to be able to do this when requisite, our next step will be to unfold more minutely their distinguishing characteristics. We begin with the Dicotyledons.†

In the *hundred and seventeenth* Theorem it is stated, " *That the Dicotyledonous class is distinguished by the existence of pith in the centre of the stem, by increasing exogenously, and*

* Edinburgh Journal of Natural History, p. 18.

† This, according to some botanists, is *Sub-Class* 1st of Class 1st, Vasculares, or Flowering Plants.

by medullary rays proceeding from the centre of the circumference of their woody parts. That the seeds are furnished with two fleshy lobes called cotyledons attached to a rudimentary germ concealed between them."

By this definition it will be observed that the plants composing the *Dicotyledonous* class possess numerous peculiarities of construction, by which they can be distinguished from the other two. But the characteristics to which we are most desirous of directing the attention for the present, are their *manner of seeding*, and the *construction of their stems*, for on those two points will hang the burden of the proof required to substantiate our future argument. Therefore, with this design, as well as with that of preparing the way for certain explanations which are to follow, we beg the reader's attention while we submit a brief, but instructive detail of the *reproductive* organs of the *phanogamous* plants in general.

The writer on Botany in the Library of Useful Knowledge, already alluded to, says—

"All the parts hitherto treated of belong to what are called the *organs of nutrition*, or of *vegetation*. . . . . . . Everything which is developed subsequently to the leaves, belongs to the *organs of reproduction*, or of *fructification;* the sole office of which is to secure the perpetuation of species by Seed, an action they are enabled to perform by the nutritient properties of the stem and leaves. . . .

"A perfect flower consists of three principal parts; namely, the *floral envelopes*, the *fructifying system*, and the *fertilizing system*. Of these, the two last are always present, either both together or in separate flowers; the first may be either present or absent, not being absolutely essential to a plant. The floral envelopes, generally, consist of two different parts, the *calyx* and the *corolla*. . . . . .

"When the *Calyx* is distinguishable from the corolla, which is not always the case, it is commonly known by being smaller, greener, and more leaf-like, or more permanent. But such characters will not invariably indicate it. In fact there seems no means of defining the calyx better than as the most exterior whorl of the floral envelopes; and, consequently, the name is so applied, whatever the colour, size, or other characters of the exterior whorl may be; and hence, if there is only one whorl, that one is the *calyx*. . . . . .

"The *Corolla*, although it is only to be known with certainty

from the calyx by its being placed between that part and the stamens, is often, nevertheless, the most conspicuous part of the plant, because the gay colours and the fragrant odours of flowers are generally resident in it. . . . . .

" The office of the floral envelopes is in part to act as a protection to the fertilizing and fructifying organs when they are young, and to guard them from sudden variations in temperatures, being interposed between those parts and the atmosphere. . . . . .

" The *Fertilizing system*, called by many modern writers the *andræceum*, consists of organs which are technically named *stamens*, and usually consist of two parts, viz.—a slender white stalk, or *filament*, and a yellow or brown head, or *anther*, which is the essential part; the filament being of no more importance to the latter than the footstalk to the leaf.

" An accurate idea of the normal state of the filament and anther may be taken from the lily. In that plant the *filament* is a long, fleshy, awl-shaped, greenish-white body, the surface of which is furnished with stomates, and the centre with a bundle of vessels. On its point is placed the *anther*, which is a narrow reddish-brown body, having a deep furrow passing down its longer diameter, and being thus separated into two parallel lobes. The part that unites the lobes is a continuation of the filament, and is called the *connective*. Each lobe before it opens, is marked in front with a shallow furrow, which passes from end to end of the lobe. In course of time the sides of the lobe contract and separate at the last-mentioned furrow, which consequently opens and allows a brownish-orange powder named *pollen* to fall out ; the two sides of the lobe when they thus separate are called *valves*, and the furrow itself the *suture* or *line of dehiscence*. . . . . This may be considered typical of all filaments, and of all anthers. Both these parts are, however, subject to numerous important modifications. . . . . .

" The *Pollen*, which looks like very fine dust, is the most curious and varied part of vegetation. It consists of a multitude of little grains, whose figure, generally uniform in the same species, have some hundred modifications of form in different species, and vary in size from the 1-30th to the 1-240th of a line in diameter. . . . The matter which is ejected from the pollen appears, under a microscope of low power, to be merely a turbid fluid, denser than the water into which it is discharged ; upon magnifying glasses of sufficient power being applied, it is found to consist of oblong particles about the 1-5000th part of an inch in diameter, and spheroidal molecules

varying in size from the 1-15,000th to the 1-25,000th of an inch in diameter, according to the computation of M. Dollond. It is generally believed that these particles are the rudiments of embryos, and that the effect of fertilization is to convey one of them into the ovule.

"The *Fructifying system*, or *gynæceum*, is the part round which all the other parts are arranged; it is generally the *pistil*, and consists of certain component parts called *carpels*, which are either distinct from each other, or all grown together into one body; or, if the pistil consists of but one carpel, then the terms pistil and carpel have the same meaning.

"A carpel consists of *ovary* and *ovules*, *style* and *stigma*. The *ovary* is the lower portion, which is hollow, and within which is a double line corresponding with an external suture, and called the *placenta*. The ovary tapers upwards into a slender horn or thread, called the *style*, on the point of which there is a humid space, destitute of cuticule, which is the *stigma*. Of these parts the *ovary* and *stigma* are present in all *carpels*, but the style is not absolutely essential.

"The *Stigma* is subject to alterations, but generally it is undivided, and consequently the number of stigmas indicates the number of carpels, of which a syncarpous pistil consists. . . . . .

"To the naked eye the *Ovule* is an oval grain of a mother-of-pearl colour, and seems merely a bag of gelatinous matter; but in reality it is an organ whose structure is by no means so simple. It consists of a central part, called the *nucleus*, over which are placed one, two, three, or four membranes, called from their position the *primine*, *secundine*, *tercine*, and *quartine*; the *primine* being the most external. . . . . .

"The *Fruit* of a plant is the fertilized *ovary* arrived at maturity, and consequently both organs must have the same structure in all their more essential points; for the plan upon which the ovary is to be constructed is finally determined at the period when fertilization takes place. . . . . .

"We proceed next to some observations upon the normal condition of the fruit. . . . . . Some descriptions of fruit are always closed up to the latest hour of their existence, as the cocoa-nut; others have the property of bursting into separate pieces or *valves* when ripe. . . . . .

"In order to avoid circumlocution, the numerous varieties which occur among fruits have been classified by botanists, and names given to the most important of their modifications.

"The *Follicle* may be considered as a carpel in its ripe state, opening by its ventral suture only, and consequently to be typical of all modifications of fruit, as the carpel itself is of all modifications of pistil.

"The *Legume*, is hardly susceptible of a definition, so various the forms under which it occurs. Its most genuine state is as we find it in the pea, where it is a follicle opening by both dorsal and ventral sutures into two valves. . . . . . Such legumes as separate transversely into distinct pieces are sometimes called *lomenta*, or *lomentaceous*.

"The *Achenium*, or grain, is a carpel which is one-seeded, does not open when ripe, and has no suture at all. It is what the old botanists called a naked seed, because it resembles a seed in size and texture.

"A *Cariopsis* is an achenium with a thin shell, which grows so close to the skin of the seed as to be inseparable and undistinguishable; such is the fruit of wheat, maize, and other kinds of corn.

"A *Utricle*, is a cariopsis with a thin loose shell; it would be an achenium if the shell were hard; it occurs in goosefoot (*Chenopodium*), and often divides transversely.

"A *Nut* is an achenium in everything, except that it results from a compound pistil, and is really composed of several carpels, although all of them may be abortive except one. The hazel-nut, the chesnut, the acorn, are familiar instances of this.

"The *Key* is either an achenium, or a nut with the summit expanded into a wing, as in the ash and sycamore.

"The *Drupe* is an achenium with the shell separable into two layers, of which the inner is hard and bony, forming a *stone* or *endocarp*, and the other soft and juicy, forming a flesh. The fruits of the peach, the plum, the cherry, are drupes. The walnut is a drupe, the endocarp of which separates into two valves, each of which has an imperfect spurious dissepiment projecting from the back, and cutting the seed into deep lobes.

"The *Berry* (bacca), is composed of several carpels, which, when ripe, are a mere mass of pulp, in which the seeds lie buried, as the grape and the gooseberry.

"The *Gourd* (pepo), is a berry with a hard rind, like a melon.

"The *Pome* is a sort of fleshy berry, in which the inside of the cells is dry, so that the seeds do not lie in the pulp; it is composed of a few carpels surrounded by a fleshy calyx, to which they grow, and may either have a thin and papery, or a thick and bony lining

to its cells. The former, which occurs in the apple, may be considered as a combination of fleshy follicles with a fleshy calyx; the latter, which we find in the medlar, as a union of drupes to a fleshy calyx.

"The *Siliqua* is a dry fruit, with two valves that separate from a frame to which the seeds are attached; in the cabbage it is long and narrow; in the shepherd's purse it is short and broad.

"Finally, the *Capsule* is a general term for all dry fruits which are composed of more carpels than one, and which dehisce when ripe; its application is even extended by combining it with modifying words; thus a *berried* capsule is a fruit having the ordinary structure of a capsule, with a soft juicy shell, and not dehiscing; and so on. Taken in its most general sense, it is the most variable in appearance of all the organs of fructification.

"Besides the foregoing, there are several fruits which are not produced by single flowers, but which are formed by the adhesion of a considerable number of flowers into a single mass. Such is the fir-cone, the pineapple, and the mulberry. These may either be considered as varieties of the *strobilus*, or cone; or with some others may be looked upon as forming a section in a methodical arrangement of fruits, in which latter case they would have several different names.

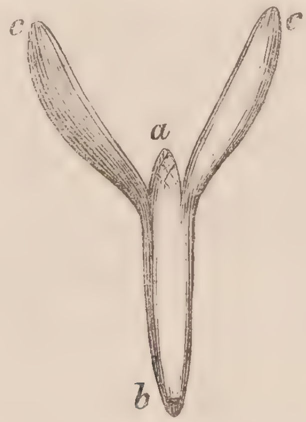
"The *Seed*. While changes are coming over the pistil, the ovules are also undergoing a metamorphosis still more interesting and important. No sooner has the mysterious influence of the pollen been introduced into the ovule, than its foramen closes up; its integuments extend and harden, the pulpy substance within them consolidates, and in the midst of the latter, within the kernel, close to the foramen, there appears a minute, yellowish, opaque speck, which gradually enlarges and projects forwards into the centre of the kernel, absorbing the fluid that surrounds it, and, by degrees, assuming the appearance of an organised body which it ultimately becomes, in the form of an *embryo* plant.

"The interior integument, within which, under the name of kernel, all this goes on, absorbs its food from the placenta. . . . . . When fully formed, the seed separates from the placenta, retaining a scar, called the *hilum* or *eye*, at the spot where the separation takes place. . . . . . The embryo is originally formed in the midst of the pulpy substance of the kernel, and is nourished by it during its growth. This pulpy matter bears apparently much the same relation to the embryo plant as the white of an egg to an embryo bird; and hence

it has obtained the name of *albumen.* Usually this substance is so wholly absorbed by the embryo that no trace of it is left behind. . . .

"From what has gone before, it is clear that the ovule is the origin of the seed; and as nearly all ovules are originally enclosed within a carpel, there can be no such thing as naked seeds except in a very few instances. What the old botanists called naked seeds were usually achenia; and true naked seeds are hardly known beyond coniferous and cycadeous plants.

"The *Embryo* is so extremely varied in its structure that it is absolutely necessary to take some one form as typical of the remainder, if the endless modifications it exhibits are to be correctly understood. For this purpose let *a b* of the following figure represent the central portion or axis of any embryo, and *c c* two *seed-*



leaves called cotyledons, growing from it. The part from *a* to *b* will then represent a stem, of which *a*, called the *plumule*, is the growing point; *b*, the *radicle*, is the root; and the intermediate space between the radicle *b*, and the base of the cotyledon *c*, an internode; upon which supposition the plumule will be auxiliary to both cotyledons at once. From this form of embryo all our ideas of that organ may be derived; it represents more particularly what is called a *dicotyledonous* embryo, in which not only there are two cotyledons, but they are opposite to each other; let the number of cotyledons be increased, all other things remaining as before, and it is *polycotyledonous*, as in fir-trees. . . . . Commonly, the embryo is straight, or but slightly curved; but in certain plants it is rolled up in a singular way."* . . . . .

Professor Henslow says—

"Beans, peas, almonds, the kernel of our stone fruits, &c., afford

* Botany, in Lib. Useful Know. p. 9, et seq.

us familiar examples of the structure of the seeds of *dicotyledonous* plants. When the outer skin is removed, we find that they are composed of two large fleshy lobes termed 'cotyledons,' which are attached to a small rudimentary germ almost entirely concealed between them. The entire mass forms the 'embryo,' and the skin which invested it the 'seed cover.' "*

Having thus become minutely acquainted with the Seeding processes of Dicotyledonous plants, we shall, from the same authorities, briefly describe how their stems are formed, and the manner of their increase, whence they derive the name of "*exogens*."

"The central part, or axis, of a plant," says the distinguished botanist we have been quoting from, "to which the leaves and flowers are attached, is technically called the *caudex*, to which the English word *trunk* seems equivalent, notwithstanding its being generally applied to the thick bole of a tree.

"It consists of two portions; the ascending trunk, or *stem*, and the descending trunk, or *root*. Between these there is no absolute separation, each being an extension of the other in an opposite direction; the ascending trunk, or stem, having from its earliest existence an invincible tendency to grow upwards into the air and light, the descending trunk, or root, an equally irresistible determination to the earth, away from the light. . . . . .

"In their internal structure roots and stems are nearly alike, except that the former are rarely hollow, although many stems are; and that in the plants called *exogens*, which have a pith in the centre of their stem, the root has no pith. . . . . . In most plants the stem is solid: in grasses and umbelliferous plants it is hollow."

Having so recently given an explanation of the internal structure of the stems, and of the primary forms to which their variations are referable,† a repetition here may be avoided, and we shall therefore pass on to a brief examination of each respectively.

"A stem formed upon the *exogenous* plan, when cut through trans-

* Botany, in Cab. Cyc.

† See pages 188, 189.

versely, exhibits a central *pith*, surrounded by one or more circles of *wood*, on the outside of which is a ring of *bark*, which is connected with the pith by a number of lines passing through the wood called *medullary processes*. . . . . . In plants whose stems exist only for a single year, there is but one circle of wood; and if such stems are very succulent, it may even be difficult to ascertain the presence of wood at all. But it will always be found, upon close inspection, that some trace of woody matter exists, arranged in a definite manner between the pith and the bark. . . . . Let us briefly examine the structure of the various parts that make an *exogenous* stem.

"The *Pith* is a spongy column which extends from the collar, where it usually ceases, to the extremities of the branches. When young it is succulent; when old it becomes dry. . . . . . . It is united with the *medullary* rays or plates, or *processes*, as they are more correctly called, by an infinite multitude of points arising from over all its surface. . . . . . .

"The *Medullary Processes* which thus arise from the pith, of which in fact they are mere extensions, pass straight into the bark, cutting the intervening wood into a number of wedges, the broad end of which is next the outside of the stem. . . . . .

"The office of these *processes* is very important. They are the great means of communication between the circumference and the centre of a stem, and are what enable the fluid matter, which passes down the bark, to reach the wood which is next the pith. Their component parts are placed with their longer diameter perpendicular to the bark; a position which is the most favourable to perform their functions. . . . . .

"The *Bark* consists of an external layer of a spongy substance which is usually green, and of an interior layer of fibrous matter which touches the wood. Of these layers the external is called the cortical integument, and the interior the *liber*. Every year an addition of new *liber* is made, in the form of a concentric zone within that of the preceding year. . . . . . It is through the bark exclusively that the returning fluid of a plant descends to the root; and it is in this part that many secretions are chiefly stored up. . . . .

"The nature of the *wood* will be best understood by examining the structure of a single zone, and considering all the other zones subsequently formed to be merely repetitions of it. Next the pith is placed what is called the *medullary sheath*, which is a stratum of air vessels forming a sort of casing to the pith, but interrupted perpetually by the medullary processes which pass through it. On

the outside of the medullary sheath is a mixture of large vessels and fibrous matter, the former predominating; and on the outside of all, finishing the concentric zone, is a deep mass of fibrous matter, with a number of small vessels intermixed; in all the other zones exactly the same structure is repeated as long as the plant continues to grow; so that the trunk of the largest exogenous tree is a mere repetition of woody or cortical zones; the youngest of the latter being formed within-side the older, and the youngest of the former outside the older. . . . . . In some plants, scarcely any vessels are to be distinguished among the fibrous matter of the wood, or there is but little apparent distinction between the different zones; but, in the main, the structure just described is that of *exogens* in general."*

Whatever degree of attention may have been given to the perusal of these leading characteristics of the plants composing the class occasionally termed Exogenæ, but more usually Dicotyledons, it will have been sufficient to convince any one that none of them could have existed during *the long, but indefinite preiod when the earth was without rotation, enveloped in darkness, and circumbounded by water.* They all require light, atmospheric air, and dry land;† not only for their perfection and reproduction, *but even for their very existence.* It may not, besides, be inopportune to observe, with more particular reference to the woody fibre of their exogenous stems, that as "every *year* an addition of new *liber* in the form of a concentric zone beyond that of the previous one is made to them," *each zone being the material index of the vicissitudes of summer and winter, marked with undeviating precision by the finger of time within the stems of the Dicotyledons,* these zones could *not* have been formed *before* the seasons were instituted by the lighting up of the sun, by the same Omnipotent Being who chose to reserve this central orb in darkness for many ages; of which event we thus acquire additional and concurring testimony by every new object of investigation.

It will also have been observed that under whatever deno-

* Lib. of Useful Knowledge, pp. 9—16. In order to restrict these quotations within due bounds we have been obliged to curtail them more than we otherwise would. Their perusal, in the original, would amply repay the reader.

† Theorems 118 and 120.

mination the plants composing the *Dicotyledonous* class may be called, they all "produce fruit whose seed is in itself;" whether we designate them as the *legume*, or that implied by it, the bean, or the *pea;* or by *drupe*, *nut*, *glaus*, *capsule*, *berry*, or *pomum*,* they are all alike—"fruit after his kind whose seed is in itself upon the earth;" and, consequently, whether these are produced in a tree as majestic as the *oak*, or as diminutive as the *radiola millegrana*, they alike come under this clear and comprehensive classification. Indeed, there is no definition which, in so few words, can be made to group together, by one common characteristic, such an infinite number and so great a diversity of plants as those composing the *Dicotyledonous Class:* while the wonderful wisdom which selected the *fruit* or *seeding processes* as the one grand common feature, becomes the more apparent when it is remembered *that all the other parts of the plant are subservient to this one essential object—the means of perpetuating itself by reproduction;* and that, however diversified the intermediate processes may be which lead to this, they all meet, as it were, by myriads of distinct approaches at this common comprehensive resting-place—"*Fruit after his kind whose seed is in itself.*"

It is scarcely necessary to remind the reader that the *Dicotyledons* constitute a great proportion of the plants of the earth, that they are much diversified in different countries, some being more common to one part than to others; and, what is still more remarkable, it appears pretty well established by the concurring testimony and the researches of botanists, that there are plants of this class, as well as of the *Monocotyledonous* kind *peculiar* almost exclusively to certain localities and detached islands, showing that there have been distinct foci of creation in the vegetable kingdom. This fact is very essential to be borne in mind, and we beg it may be noticed, as we shall have occasion to recur to it in another place.

As it may be conducive alike to unity of design and to the attainment of a more perfect knowledge of this great division of the vegetable kingdom, to enumerate the several *orders* which are comprised in it, we do so, selecting for that purpose,

* 119th Theorem.

and for motives which shall hereafter be explained, the classification given by Sir William Jackson Hooker in the *Flora Scotica;* in which he commences with the imperfect, and goes up to the *Vasculares*, or *Flowering Plants.*

Accordingly, *Class* III. are DICOTYLEDONS, and are thus described :—

"*Embryo*, with two or more *cotyledons*, *plumule* in the centre of their point of junction; the inferior end of the *embryo* itself elongated into a *radicle*, and not containing any secondary *radicles* in its substance. *Stem* increasing by external layers or additions, with an evident distinction between bark and wood. *Leaves* usually varied, rarely nerved."

The following numerous Natural Orders are classified under this division, namely :—

1. Coniferæ
2. Corylaceæ
3. Salicinæ
4. Ulmaceæ
5. Urticeæ
6. Aristolochiæ
7. Euphorbiaceæ
8. Rosedaceæ
9. Thymeleæ
10. Polygoneæ
11. Clenopodeæ
12. Plantagineæ
13. Plumbagineæ
14. Primulaceæ
15. Lentibulariæ
16. Verbenaceæ
17. Melampyraceæ
18. Labiatæ
19. Scrophularinæ
20. Orobancheæ
21. Solaneæ
22. Boragineæ
23. Convolvulaceæ
24. Polemoniaceæ
25. Gentianeæ
26. Apocineæ
27. Oleineæ
28. Ericeæ
29. Vaccineæ
30. Monotropeæ
31. Campanulaceæ
32. Compositæ
33. Dipsaceæ
34. Valerianeæ
35. Rubiaceæ
36. Caprifoliaceæ
37. Lorantheæ
38. Umbellifera
39. Saxifrageæ
40. Grossulariæ
41. Halorageæ
42. Onagrariæ
43. Cucarbitaceæ
44. Salicariæ
45. Illecebreæ
46. Rosaceæ
47. Leguminoseæ
48. Rhamneæ
49. Celesstrineæ
50. Hypericinæ
51. Aceraceæ
52. Tiliaceæ
53. Malvaceæ
54. Geraniaceæ
55. Oxalideæ
56. Balsamineæ
57. Lineæ
58. Caryophylleæ
59. Sempervivæ
60. Portulaceæ
61. Droseraceæ
62. Cisteæ
63. Violaceæ
64. Polygaleæ
65. Cruciferæ
66. Fumarieæ
67. Papaveraceæ
68. Nymphyaceæ
69. Berberideæ
70. Ranunculaceæ*

* Flora Scotica, pp. 194, 297. We consider it almost superfluous to point

Before concluding this part of the subject, it may be well to bring before the mind the perfect conformity in the condition of the earth at the period when it is recorded that this class of the Vegetable Kingdom, which require, as we have seen they do, light, atmospheric air, and dry land for their existence and perfection.* The inspired historian reveals to us that they were willed into being on the latter part of the third day, that is, after the primary light, the atmosphere, and dry land had been formed—"And God said, Let there be a firmament in the midst of the waters, and let it divide the waters from the waters. And God made the firmament, and divided the waters which *were* under the firmament from the waters which *were* above the firmament: and it was so. And God called the firmament Heaven. And the evening and the morning were the second day. And God said, Let the waters under the heaven be gathered together unto one place, and let the dry *land* appear: and it was so. And God called the dry *land* Earth; and the gathering together of the waters called he Seas: and God saw that it was good."†

With us this amounts to positive convincing proof; with others it may not be allowed greater weight than presumptive evidence; while, with not a few, we fear, it will scarcely be admitted as evidence at all, until the conviction of its authen-

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out, that as this flora is confined solely to Scotland, there must, of course, be a great many more Natural orders, both in the Monocotyledonous and Dicotyledonous divisions in other countries, besides those which are detailed by Dr. Hooker. It will, however, be seen in the sequel, that our object shall have been fully attained should a conception be acquired of the kind of plants which usually are classed in those two divisions, especially in the *first*, and by establishing determinately the Natural orders which belong to the *Acotyledonous* division, on which our future argument will materially depend. Fortunately types of all those in this last division which are known in any country are likewise found in Scotland—one of the chief motives for our having selected the *Flora Scotica* as a text book.

* Theorems 118 and 120. MM. Lindley and Hutton, when reasoning respecting the probable state of Melville Island during the ancient epoch, and showing the impossibility of such plants as are found in those latitudes growing there now for want of light, say, "For light is an agent without which no growing plants can exist, at the present day, for a single week, even in a low temperature, without suffering serious injury."

† Genesis, i. 6—10.

ticity breaks in upon them, when their tardy willingness to believe it, alas! will be of little avail. It is distressing to think how faint, even now, the evidence of the Word of God, the Omnipotent Creator of all things, appears to the minds of many, when contrasted with the mere conclusions of philosophy; the reality passing for a dim and distant shadow; the philosophical conclusions for a reality. The day will come, however, and we hope is not very distant, when it will be the chief wisdom of the philosopher, while he investigates into and admires the works of the Creator, to pore over the writings of the inspired volume in a proper and necessary frame of mind, and endeavour to comprehend and to apply the words of God to unravel what, otherwise, may appear mysterious in His works.

We must now proceed to acquire a knowledge of the characteristics which distinguish the MONOCOTYLEDONOUS class,* the second division of plants according to the natural system. We shall begin by recapitulating the definition given of them in the *hundred and sixteenth* Theorem: "*That in the Monocotyledons—consisting of several orders—there is no distinction between the pith, the wood, and the bark, but their stems consist, generally, of a cylindrical, though sometimes of an angulated mass of cellular tissue, in which are bundles of vascular tissue, without medullary rays. That they are called Endogenæ, from the newly-formed material devoloping itself towards the innermost part of their stems. That an albuminous mass forms the main bulk of most of the monocotyledonous seeds, having the embryo placed within it; the general character of these seeds being that of a cylindrical body tapering towards the extremities, from one of which, in due time, protrudes the radicle, and from the other arises a single, conical, and almost solid cotyledon.*"

In order to acquire a somewhat more intimate knowledge of the structure, properties, and habitudes of the numerous and delicate plants composing this group, it will be necessary for us to go into a few details to enable us hereafter to judge

* By some botanists this is called *Sub-class* second of CLASS first, VASCULARES; or FLOWERING PLANTS.

of the correctness of the conclusions deduced from them. First, of the Seeds.

"The general structure of the seeds of the Monocotyledonous class of plants," says Professor Henslow, "may be exemplified by the examination of a grain of Indian corn, wheat, &c.; or of a seed of an onion, lily, &c. An albuminous mass forms the main bulk of most of these seeds, and the embryo is placed within it towards the centre, or one side. The embryo is not so distinctly developed in the seeds of this class as in those of the dicotyledons; and its several parts cannot always be readily recognized before germination has commenced. Its general character is that of a cylindrical body, tapering more or less at the extremities, from one of which protrudes the radicle, and from the other arises a single, conical, and almost solid cotyledon. This elongates, and is ultimately pierced by a leaf, rolled into a conical form, and which was at first completely invested by the cotyledon."*

In the *Library of Useful Knowledge* it is stated that—

"All the foregoing modifications are easily intelligible upon reference to the typical form of the embryo; but there are others called *Monocotyledonous*, because they have only one cotyledon; in which the analogy between them and the supposed type is at first sight not apparent. Take, for instance, the embryo of a cocoa-nut; it is a taper, fleshy body, somewhat club-shaped at one end, and abruptly blunted at the other; no trace of cotyledon, plumule, or radicle is externally discoverable. If, however, it is divided with a thin and sharp knife from top to bottom into two equal parts, it will be found that near the blunt end there is an internal conical tumour directed upwards: this is ascertained by the germination of a cocoa-nut to be the young *plumule*; and this being known, it follows that the abruptly blunted end of this embryo is the radicle, and the other the cotyledon; hence it derives its name of *Monocotyledon*."†

"*Endogenous* stems apparently differ very much from exogens, for they have neither pith, nor medullary processes, nor bark, nor wood, properly so called; but consist of a confused mass of bundles of woody substance lying in the middle of a spongy matter. In the palm we find an external cortical integument without liber; the

* Botany, Cab. Cyc. † Ibid, p. 56.

bundles of woody matter so arranged as to be much more numerous and compact at the circumference than towards the centre. In the cane, which is another kind of palm, the woody bundles are distributed equally throughout the whole substance. In the asparagus, the aloe, and other soft-stemmed species, the woody bundles are not only equally distributed, but are so soft as to be scarcely recognized for the same thing as the hard fibres of a palm stem. Now, if we compare a stem of this sort with that of an exogen, we are, at first sight, unable to discover any analogy between them; but upon a more careful inspection it will be discovered that the principal organic difference consists in the woody matter of exogens being arranged in wedge-shaped parcels plunged into the spongy substance of the stem, and disposed in annual zones; while in the endogens the woody matter is neither collected into wedge-shaped parcels, nor arranged in annual concentric zones, but is broken up into fibrous bundles plunged without order into the spongy mass. . . . . . . Another, and a more remarkable deviation from the general structure of endogens, is met with in grasses, the stems of which are generally hollow between the nodes where the sides are connected by transverse partitions; but the arrangement of matter in the solid shell being entirely that of palms, grasses cannot be considered to offer an exception to the law of endogenous structure.

"Arborescent *Endogens* being exclusively natives of hot countries, where Europeans have seldom an opportunity of examining minutely into matters which require the long and patient investigation of resident observers, nothing certain is known of the channels through which the ascending and descending currents pass in their stems. From analogy it is presumed that the sap rises by the woody bundles, and descends through the soft spongy matter; but this is entirely conjectural."*

In continuation of our investigation, and of the working out of the problem which we are so desirous to solve, we shall briefly enquire what ORDERS of plants are grouped together under the denomination of MONOCOTYLEDONS or ENDOGENS; and whether they are of the description which are commonly called "*herbs*." Professor Henslow has asserted as an axiom "That the proportion of *Dicotyledons* to *Monocotyledons*, and of woody species to the herbaceous *increases* as we approach to

* Library of Useful Knowledge, pp. 17, 18.

the equator:" consequently, we have only to reverse the axiom to be made aware, that a northerly region will more greatly abound with *Monocotyledons;* and, applying this to practice, we shall appeal to the *Flora Scotica* as the most apposite text book to which we can refer for the purpose of enquiring whether MONOCOTYLEDONS may be considered HERBS. The following orders and their characteristics are taken from the work in question:—

CLASS II. MONOCOTYLEDONS.

ORDER I. *Gramineæ.—Stems* fistulose, generally simple, and herbaceous, sometimes branched, rarely shrubby.

II. *Cyperaceæ.—Stems* slender or triangular; sometimes with an indefinite number of angles, usually without joints, sometimes jointed and branched.

III. *Restiaceæ.—Herbs,* or under shrubs.

IV. *Junceæ.*—In conspicuous herbs with small flowers, which are often brown, rarely petaloid.

V. *Butomeæ.*—Not particularised; but *Butomus* is an herbaceous plant.

VI. *Melanthaceæ.*—Not particularised; yet *Tofieldia,* which is one of the genera of Melanthaceæ, is described as 'scarce a span high.' (p. 14).

VII. *Asparageæ.*—Not particularised; but *Asparagus, Ruscus, Convallaria,* and *Paris,* are all herbaceous.

VIII. *Asphodeleæ.*—Not particularised; but *Ornithogalum, Scilla, Hyacinthus,* and *Allium,* which are of it, are decidedly herbaceous.

IX. *Lilliaceæ.*—Not particularised; although *Tulipa,* which is in it, is herbaceous.

X. *Amaryllideæ.*—Not particularised; yet *Narcissus,* and *Gelanthus* are both herbaceous.

XI. *Irideæ.—Herbs,* rarely under shrubs.

XII. *Alismaceæ.*—Aquatics.

XIII. *Hydrocharideæ.*—Also aquatics.

XIV. *Orchideæ.*—Stem simple; rarely divided, leafy or sheathed.

Order XV. *Aroideæ.*—Herbs or under-shrubs.
XVI. *Juncagineæ.—Rigid herbs* with narrow radicle leaves.
XVII. *Fluviales.—Floating herbs*, with very vascular *leaves* and *stems.*

In describing generally "The Organization of the Stems" of this class, Professor Henslow says—

"In *Monocotyledons* there is no distinction between the pith, wood, and bark; but their stems consist of a cylindrical mass of cellular tissue, through which bundles of vascular tissue are distributed in a scattered manner. Every fresh development of new matter is carried towards the centre of the stem, and, as the stem elongates, the outer parts become more and more solidified, whilst the inner remain soft. These stems possess no traces of medullary rays. The plants of this class are termed '*Endogenæ*,' from the circumstance of the newly-formed materials being always developed towards the innermost part of their stems. A piece of cane is a familiar example for illustrating this structure; but we have no woody plants in our climate belonging to this class; and very few even which possess herbaceous stems, if we except the hollow culms of the grasses, where the development of the materials towards the centre is not sufficiently rapid to keep pace with the elongation of the stem, and the tissue is in consequence ruptured."*

These investigations, conducted in so detailed a manner, of the seeding processes, the construction of the stem, the formation of the leaves, and the designation as *herbs* of the second natural division of the vegetable kingdom, all concur in proving that, when compared, they agree in every possible point of view, with their simple but comprehensive classification in Genesis, so often referred to—"*the herb yielding seed after his kind upon the earth.*" They come up completely to, but do not exceed, those standard characteristics. They are herbs bearing seed; but are not trees bearing fruit with seed in itself. To produce seed they require to flower, and although some are aquatic, yet they all flower in the open air, and require sun-light to enable them to perform their various func-

* Botany, in Cab. Cyc. pp. 34, 35.

tions: consequently they stand in the same relative position with respect to the darkness and circumfluent ocean which enveloped the primitive earth, as do the *Dicotyledons.* Like them, they could not have grown while the globe was in that condition; and, for the same reason, the period they are recorded as having been brought into existence—that is, after the light and the atmosphere had been formed, and the dry land separated from the waters—is peculiarly and convincingly appropriate.

We have now, however, to look upon those two great and comprehensive classes—the DICOTYLEDONS and MONOCOTYLEDONS—in another point of view, and one which leads to considerable intricacy and difficulty. *They seem, between them, to embrace the whole of the plants recorded to have been formed by the earth, in consequence of the powers conferred upon it by the Almighty, on the latter part of the third day of the Mosaic week:* the one referring especially to "herbs yielding seed;" the other comprehending all "fruit trees yielding fruit after his kind whose seed is in itself upon the earth;" and thus *they oblige us to look to the previous creative influences of the Divine will, for the origin of all plants which do not fulfil either of those two conditions.*

In working out the conclusions to which these remarkable and apparently embarrassing facts may lead us, whatever may be the obstacles we shall have to encounter—and we fear from the difficulty of classifying some of the flowerless, leafless, imperfect plants of the cryptogamic orders, these obstacles may neither be few nor easily overcome—we must not allow ourselves to be deterred, as this would imply less than due reverence for the Almighty. For, by the evidence of our senses we are constrained to admit that there were numberless varieties of plants in existence for ages before He chose, for His own wise and gracious purposes, to *record* the last act of creative influence with respect to the vegetable kingdom; and therefore, in shrinking from, or even in being fearful to assume such a position, which is borne out by undeniable evidence, we do despite alike to the power and to the wisdom of the Omnipotent Creator. As far as such hesitation has any weight or any value, it goes to detract from the perfection of the

creation, and to circumscribe His acknowledged power. If we willingly concede that God did create those plants which produce seed, and those trees which bear fruit with seed in itself—and we do not see how either can be denied—it would amount to nothing short of a want of consistency to deny His having previously willed into existence those other descriptions of plants required for the progressive perfection of the work of creation, when, "in the beginning He created the heaven and the earth," although we have not been expressly told when or how they were brought forth, during the dark and submerged condition of the earth. Our senses convince us indubitably, *that they were there;* reason and analogy point out to us their uses and their habitudes; while Revelation leaves us not the semblance of a motive for either doubting their existence, or for attributing their creation to any other than to God.

With this explanation, and begging it may be borne in mind, that our chief difficulty will arise from that which is experienced in classifying the objects of research, in consequence of their imperfect nature, we shall now proceed to acquire a knowledge of the Third, or remaining division of the Plants known by the denomination of ACOTYLEDONS. Before commencing this, it may be well to observe, that a material difference exists between the more perfect tribes of the *Acotyledons*, called *Ductulosæ*, which are reproduced by flowerless sporules (substitutes for seeds), although possessing neither radicle nor plumule—such as those of ferns, mosses, marchantia, &c., and the still less perfect and more simple forms of the *cryptogamia*, termed *cellulares*, among which are *fungi*, *lichens*, and *algæ*, whose manner of reproduction is involved in obscurity and uncertainty;* while it is also to be remarked, that the lower we proceed on the descending scale, the less dependent these plants seem to be on the influence of light, and the more attached to dampness and moisture, until we come to an *order*, the *Algæ*, whose natural element is water.†

According to the *hundred and fourteenth* Theorem, which treats of the *cryptogamous* plants, they are distinguished as

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* See this difference stated in a propositional form in the 115th Theorem.
† Pop. Hist. of British Algæ, by the Rev. Dr. Landsborough, 1849.

follows:—*The Acotyledonous or Cryptogamous Class includes an extensive series of plants, grouped under several Orders, differing considerably in many particulars, but the whole agreeing in the important circumstance of never bearing flowers. That, having no flowers, they produce no true seeds, but, in lieu thereof, the higher tribes are furnished with minute granular bodies, capable of becoming distinct plants, called sporules; not separable into distinct parts with radicle, plumule, and cotyledons, like the seeds of phanogamous plants. That these sporules possess the power of producing from any part, either stem or root, as circumstances may require, while it is quite otherwise with true seeds. That acotyledonous plants increase acrogenously.*

We shall commence the evidences in support of this *Theorem* by quotations from a work which recommends itself by its intrinsic merits, and by the care and assiduity bestowed by its author on the *Cryptogamic* class of plants, in a field of labour where they peculiarly abound—we allude to the *Flora Scotica*—while the evidences to be adduced will likewise prove, that the *Tripartite* division, pointed out by the internal structure and general formation of the stems, leaves, and floral envelopes, is not an arbitrary, but a natural classification; for when the divisions into which the various objects of the Vegetable Kingdom arrange themselves, when their *seed lobes and sporules, or modes of germination*, are made the criterion of separation, it will at once, and with satisfaction, be observed, that they are in perfect unison with that which the stems and leaves previously pointed out.

The *Second* Part of the work in question is devoted to the *Natural* Arrangement; and "here I may claim," says Sir William Hooker, "the merit of being the first who has made such an attempt with the indigenous plants. This section begins with the *Cryptogamia*, which in the Linnæan system immediately follows the 23rd class, or the last included in the first part of the work, and may thus be said to occupy its right place, whichever method of classification may be followed."*

* Preface to the Flora Scotica, pp. ix. x.

"PART II.

"Class I. Acotyledons. *Jussieu.*

"(Cryptogamia, *Linnæus.* Acotyledons, and part of Monocotyledons. Ferns of *De Candolle* and *Brown.* Agamæ and Exembryonatæ, *Richards*).

"*Fruit,* or organs of reproduction without any *Cotyledon.*

"*Vegetation.* In all, with the exception of the Ferns, the structure seems to be entirely cellular, and hence the term '*Cellulares,*' applied to them by De Candolle, in opposition to '*Vasculares,*' or those plants which, in addition to the cellular structure, have tubular vessels as in the Cotyledonous plants and the *Ferns;* on which account De Candolle and Brown have removed these into the 2nd class, or Monocotyledons.

"This class contains the following distinct Natural Orders :—

"I. Fungi. II. Lichens. III. Algæ. IV. Characeæ. V. Hepaticæ. VI. Musci. VII. Filicis. VIII. Lycopodineæ. IX. Marsileaceæ. X. Equisetaceæ."*

The botanical writer, from whose work we have already so copiously extracted, says—

"The foregoing observations have carried us, somewhat superficially, it must be confessed, but at the same time consecutively, through all the principal circumstances which occur in the life of a *perfect* plant.

"All that relates to *imperfect* plants, or those which are increased by simple division of their own substance, and not by seeds, is equally explicable by the same rules, with the single exception of their *reproduction.* Upon this head it is necessary that we should offer a few special remarks.

"It must be obvious, upon consideration, that plants in which there exists neither stamen nor pistils, and in which there consequently cannot take place any of those phenomena we have lately been examining, must also be destitute of *seeds*; for a seed is nothing but a sac of mucous matter in a particular state of organization into which either the germ of a new individual has been conveyed, or wherein its existence has been produced by some unknown action of pollen.

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* Flora Scotica, Part ii. p. 3.

"That nature has not, however, neglected the means of propagating the lower tribes of plants is plain from their great abundance in favourable situations; and, upon examination, we find that if they have not reproductive organs like those of plants of a higher organization, they are furnished with matter of another kind, which answers the purpose equally well. This matter consists of what are called *sporules* or *spores*, and is lodged in parts which may be considered analogous in their function to carpels, although they have not only no resemblance in structure to those parts in flowering plants, but also very little among each other; the spore cases being sometimes elaborate pieces of organization, as in ferns and mosses, and sometimes mere simple tubes buried in the substance of the plant, as in lichens, fungi, &c.

"In the more perfect of the tribes of flowerless plants, there can be no doubt that spores act precisely like seeds in reproducing the species; for if those from the leaves of ferns, or from the urn of a moss are sown, as they have often been, they uniformly produce the same species as that from which they were derived. In regard to these plants, then, no difference exists between seeds and sporules, except as to the origin, organization, and mode of development of the latter. Instead of having their centre divided into plumule and radicle, to which one or two cotyledons are attached, they are mere homogeneous masses of cellular substance; and instead of uniformly growing from two constant points of their substance, from one upwards and from the other downwards, *they are capable of sprouting into root or stem, indifferently from any point of their surface;* the nature of the part which the spores produce depending not upon pre-existing organization, but upon accidental circumstances. When they begin to grow, that portion of the surface which is exposed to light extends into a stem, and that which is turned to darkness and humidity becomes root. . . . . . .

"Let us not, however, be led astray by specious theories concerning bodies so far beyond the cognizance of our senses; but, in the absence of demonstrative evidence to the contrary, let us believe the great Author of Nature to be consistent with himself in all His works, and to have taken care to enable the most humble sea-weed to be multiplied by some means as certain and unchangeable as is provided for the most stately lord of the forest. We may rest assured, for all philosophy, and all observation, and all reason prove it, that there is no such thing in nature as blind chance, but that all

things have been carefully and wisely designed with reference to the particular circumstances under which they exist."*

With respect to the reproductive organs of *Cryptogamous* plants, Sir Wm. Jackson Hooker expresses himself in the following impressive words, to which we beg particular attention:—

" The more intimately we become acquainted with the reproductive organs of the *Acotyledonous* or *Cryptogamic* plants, the more apparent is it, in my opinion, that there are no sexes as in the phanogamous plants, no stamens, and no pistils, nor anything analogous to them; consequently, no true *seed*, which can only be produced through their co-operation. The structure of the *seeds* themselves (more properly *sporules*), tends greatly to confirm such an opinion; there being in reality no distinction into *cotyledon*, *radicle*, or *plumule;* in short, no embryo, any more than is in the little bulbs seen upon the stalks of the onion tribe, and on the *polygonum*, *viviparum*, &c., which yet equally produce perfect plants. *A sporule has alike the power of producing from every part, either stem or root, as circumstances may require; but it is quite otherwise with the true seed.*"†

"*Acotyledons*," says Professor Henslow, " include an extensive series of plants, grouped under several orders, which differ considerably in many particulars. The whole agree, however, in the important circumstance of never bearing flowers like those of the two former classes: hence they are termed '*cryptogamic*,' in contradistinction to '*phanogamic*,' which is applied to all flowering species. Having no flowers they produce no true seeds; but in lieu of them are furnished with what certainly bears a considerable resemblance to seed, viz.: small minute granular bodies capable of becoming distinct plants. The manner in which these 'sporules,' as they are termed, are produced, is very various in the different orders of this class, but forms no part of our present enquiry. They are also variously shaped, but generally spherical or spheroidal, and are not separable into distinct parts with radicle and cotyledon, like the seeds of phanogamous plants. In germinating, the sporules are developed by an increase of cellular tissue, which appears in the form of rounded masses and filamentous chords. Among the higher tribes roots are

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* Botany in Library of Useful Knowledge, pp. 117—119.

† Flora Scotica, Part ii. p. 3.

afterwards produced, and a part which is more or less elevated above the soil is the representative both of the stem and leaves of phanogamous plants combined. In the lower tribes, however, there is seldom any separation of parts into distinct organs, but the functions of nutrition are carried on in an obscure manner by the general mass.

" *Acrogens*, as the cryptogamia are called, are totally different in the organization of their stems from either the *Exogens* or *Endogens*. In ferns, which are most remarkable both for their size and singularity of structure, the stem is a cylinder usually hollow; if solid, having the centre filled with spongy substance, destitute of bark, with neither woody bundles nor woody wedges interposed among the general substance of the stem. The shell of this cylinder, which answers to the woody part of other plants, is composed of excessively hard plates, folded upon themselves in such a manner that a section of them represents a number of sinuous lines doubling about among spongy matter. These never increase in thickness, number, or quantity after being once formed; but they seem as if they were, as in all probability they are, mere prolongations of the woody matter lying inside the footstalks of the leaves; whereas *exogens* increase by addition to the outside of their wood, and *endogens* by addition to the inside of their stem; whence their respective names have been formed. *Acrogens* seem to have little or no power of increase in diameter, but simply to lengthen by continual extension of their points; their name has been contrived from this circumstance.

" To these principal variations of the mode of growth in the stems of plants, should, perhaps, be added a fourth form, of which little notice has hitherto been taken by botanists. This, which may be called the *centrifugal*, occurs in fungi, lichens, and the lower orders of plants; and consists of a fleshy or spongy mass, or of filamentous processes radiating from a common centre.

" In many respects this is the same as the *Acrogenous*, of which, indeed, it may be considered a mere variety; for its ramifications do not increase much in thickness after they once are formed; it nevertheless deserves to be specially explained. In an obscure plant called Marchantia, Mirbel found that a little thin green plate was first formed by the action of the reproductive grains or seedlets; and that it was from the edges of this plate, when once fully formed, that all the succeeding expansions took place, as from a common centre, but always upon the same plane; so that in such plants the central part is the oldest, and the circumference the youngest. This

is very apparent in lichens, which, when very large, are always dead in the centre, while they continue to go on growing from every part of their margin. These appearances are external indications of the centrifugal growth of the subterranean stems of certain agarics, which originally spring from a common point, continually spreading outwards upon the same plane, the central or first-formed parts perishing as the circumferential or latest-formed parts develope."*

* Botany in Library of Useful Knowledge, pp. 9—19.

SECTION III.

THE VEGETABLE ORGANISMS OF THE NON-ROTATORY PERIOD.

CHAPTER V.

Summary application of what has been established in the foregoing Chapter. DICOTYLEDONS comprehend all plants "bearing fruit whose seed is in itself upon the earth." MONOCOTYLEDONS embrace "the herbs yielding seed." But the Vegetable Kingdom being examined into, a third description of plants are discovered, bearing neither flowers, fruits, nor seeds, called ACOTYLEDONS, and these are supposed to have been created during the non-rotatory period. Lists of Fossil Plants, given in corroboration, from the chalk formation downwards, and from two distinct sources—from Geological writers, and from the works of Fossil Botanists. General observations confirmatory of these lists. Brief explanations respecting vestiges of flowering plants occasionally included in the foregoing lists. Review of the progress made thus far. Adaptation of the imperfect, flowerless plants to the state of the creation during the anti-rotatory period; and their capability of having grown and propagated in a submerged condition confirmed, by contrast with the incapability of flowering plants to have existed without either light, atmosphere, or dry land.

THE copious explanations and botanical descriptions, taken from the accomplished writers on that interesting division of natural objects, which we have given in the preceding chapter, will have sufficiently prepared the mind for accompanying us while, in this, we make the application which alone induced us to enter so fully into them. The position we shall endeavour, with their aid, to establish is—That considering the *Dicotyledonous* Class of plants comprehends indiscriminately all those "*which bear fruit whose seed is in itself upon the earth;*" and the *Monocotyledonous* division, in like manner, includes all "*herbs which yield seed;*" and that these two, together, em-

brace all descriptions of vegetable objects willed into existence *during the Mosaic week;* and, considering it to be equally well known, by reason and observation, that there does exist another great division of the Vegetable Kingdom, whose characteristics do not at all correspond with the Command which was then given; while we have no motive for supposing that the Creative power of the Omnipotent might not have been put forth at any period, or at several consecutive periods during the non-rotating condition of the Earth, we are constrained to conclude, and are prepared to prove, *that before the world revolved around its axis there did exist beneath its waters innumerable plants of great secreting powers, pertaining to, or very much resembling, the flowerless* ACOTYLEDONOUS *class of the present day, which, by means of their cryptogamic construction, and other peculiarities, were there enabled to exist, to propagate, and to acquire vast dimensions*, while as a further, and, indeed, the only effectual corroboration of this view of the case (considering the epoch to which we allude), we shall, in continuation, submit two distinct, but corresponding consolidated lists; one abstracted from M. de la Beche's manual of the fossil vegetable remains discovered in the several stratified masses, from the chalk down to the non-fossiliferous rocks of primary formation; and the other from Messrs. Lindley and Hutton's Fossil Flora, in which the objects are classed botanically, together with notes from other scientific writers on the same interesting subject. The well-established character of these authorities warrants the expectation, that perfect confidence will be placed in those lists and explanations; while the surprising conformity which they make manifest between the result of actual discoveries, and the *a priori* conclusions we have arrived at, by perfect dependence on Revelation on the one hand, and on scientific researches on the other, will, we earnestly trust, lead ultimately to the complete establishment of the truth, and to the supremacy of the Word of God over every imagination of the heart of man.

We proceed with our evidences.

" *Vegetable Organisms in the Chalk and other formations, in the descending series, viz.* :—

CONFERVÆ.

Confervites fasciculata, C. ægagropiloides, species not determined.

ALGÆ.

Fucoides orbignianus, F. strictus, F. tuberculosus, F. difformis, F. intricatus, F. Lyngbianus, F. Brongniarte, F. Targioni, F. canaliculatus, F. furcatus, F. Stokii, F. encelioide, F. Brardii, F. Selaginoides, F. lycopodioides, F. frumentarius, F. pectenatus, F. digitatus, F. antiquus, F. circinatus, and species not determined.

NAIADES.

Zosterites Cauliniæfolia, Z. liniata, Z. Bellovisana, Z. elongata.

CYCADEÆ.*

Cycadites Nelsonii.
Pterophyllum Williamsonis.
Zamia Pectinata, Z. Patens, Z. longifolia, Z. pennæformis, Z. Elegans, Z. Goldiæi, Z. acuta, Z. lævis, Z. Youngii, Z. Feneonis, Z. Mantelli.
Zamites Bechii, Z. Bucklandi, Z. Lagotis, Z. hastata.

EQUISETACEÆ.

Equisetum Columnare, E. infundibuliforme, E. dubium.
Calamites Suckowii, C. decoratus, C. undulatus, C. ramosus, C. cruciatus, C. Cistii, C. dubius, C. cannæformis, C. C. Pachyderma, C. nudosus, C. approximatus, Steinhauri, C. radiatus, C. Voltzii, and species not determined.

FILICES.

Pachypteris lanceolata, P. ovata.
Pecopteris Reglia, P. Desnoyersi, P. Polypodioides, P. denticulata, P. Phillipsii, P. Whitbiensis, P. Blechnoides, P. Candolliana, P. cyathia, P. arborescens, P. platorachis, P. polymorpha, P. Oreopterides, P. Bucklandi, P. aspera, and 34 other species.

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* The Cycadees form the passage from the *palms* to the *ferns.—Sprengel.* The Cycadeæ have great proximity to the ferns.—*Lindley.*

Sphænopteris hymonophylloides, S. (?) macrophylla, S. Williamsonis, S. crenulata, S. denticulata, S. furcata, S. elegans, S. stricta, S. artemisiæfolia, S. delicatula, S. dissecta, S. lineans, S. Brardii, S. trifoliolata, S. Schlotheimii, S. fragilis, and 14 other species.

Neuropteris Gailliardoti, N. acuminata, N. Villiarsii, N. rotundifolia, N. Loshii, N. tenuifolia, N. heterophilla, N. flexuosa, N. gigantea, N. oblongata, N. cordata, N. Schewchzeri, N. angustifolia, N. acutifolia, N. crenulata, N. macrophylla, N. oriculata.

Pteniopteris latifolia, P. Vitata.

Cyclopteris orbicularis, C. trichomanoides, C. obliqua, C. plabellata.

Lonchopteris Dournaisii, L. Mantelli,

Odontopteris Brardii, O. crenatula, O. minor, O. obtusa, O. Schlotheimii.

Schizopteris anomala.

*Sigillaria** punctata, S. apendiculata, S. peltigera, S. lævis, S. canaliculata, S. Cortei, S. elongata, S. reneformis, S. Hipprocrepis, S. Candollii, S. oculata, S. orbiculares, S. tessellata, S. Knorrii, S. elliptica, S. transversalis, and 16 other species.

Carpolithus Mentelli.

MARSILLIACEÆ.

Sphenophyllum Schlotheimii, Sph. Emarginatum, Sph. truncatum, Sph. dentatum, Sph. quadrefidum, Sph. dissecta.

LYCOPODIACEÆ.†

Lycopodites piniformis, L. Gravenhorstii, L. Hæninghausii, L. embricatus, L. phlegmarioides, L. tenuifolius, L. (?) filiciformis, L. (?) affinis, L. Lepidodendron, and several species not determined.

Selaginites patens, S. erectus.

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* By referring to vol. i. pp. xvii. to xx. of MM. Lindley and Hutton's *Fossil Flora*, our readers will find a very interesting discussion respecting this description of extinct plant *Sigillaria*, which, together with *Stigmaria*, M. Adol. Brongniart and his reviewer consider as belonging to the *Cryptogamous* class.

† Mr. Lyell, in his Glossary, p. 72, gives the following explanation of *Lycopodiaceæ* :—" Plants of an inferior degree of organization to Coniferæ, some of which they very much resemble in foliage; but all recent species are infinitely smaller. Many of the fossil species are as gigantic as recent Coniferæ. Their mode of reproduction is analogous to that of ferns. In England they are called club-mosses."

Lepidodendron selaginoides, Lep. Elegans, Lep. Bucklandi, Lep. ophiurus, Lep. rugosum, Lep. Underwoodii, Lep. taxifolium, Lep. insigne, Lep. Sternbergii, Lep. longifolium, Lep. ornatissimum, Lep. tetragonum, Lep. Venosum, Lep. Rodianum, Lep. Cordatum, Lep. Volkmanianum, and 25 other species.

Cardiocarpum majus, C. Pomiari, C. Cordifornie, C. ovatum, C. acutum.

Stigmaria reticulata, S. Weltheimiana, S. intermedia, S. ficoides, S. tuberculosa, S. rigidâ, S. minima.

Palmæ.

Flabellaria borassifolia.

Næggerathia foliosa.

Cannæ.

Cannophyllites Virletii.

Clathraria Lyellii.

Monocotyledons of uncertain families.

Stenbergia angulosa, Stenb. approximata, Stenb. distans.

Poacites equalis, P. striata.

Trigonocarpum Parkinsonii, Tr. næggerathia, Tr. ovatum, Tr. cylindricum.

Musocarpum prismaticum, M. difforma, M. contractum.

Vegetables of which the class is uncertain.

Annularia minuta, A. Brevifolia, A. fertilis, A. floribunda, A. longifolia, A. spinulosa, A. radiata. *Asterophyllites** equisetiformis, Ast. rigida, Ast. pygmæa, Ast. hippuroides, Ast. longifolia, Ast. tenuifolia, Ast. delicatula, Ast. Brardi, Ast. diffusa.

Volkmannia polystachya, V. Distachya, V. Erosa.

Dycotyledonous wood, perforated by some boring shell. Cones of Coniferæ. Ferns (?) in Green Sands.

Class uncertain.

Mammalaria Desnoyersii. Many undescribed vegetables, *Lyme Regis.*

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* No traces of them found among existing vegetables. They are named from the stellated disposition of the leaves round the branches. Buckland's Bridg. Treat. vol. i. p. 479.

CONIFERÆ.

Thuyites divancata, Th. expansa, Th. acutifolia, Th. Cupresiformis.
Taxites podocarpoides.

LILIA.

Bucklandia squamosa.

Being desirous of affording every information to our readers; and considering that a degree of cross-examination into the facts of the case may lead to more thorough conviction; we shall, in continuation of the lists now given of FOSSIL PLANTS, as they are grouped together *geologically*, present an abstract list of the same fossils arranged *botanically* by Messrs. Lindley and Hutton. As we shall confine ourselves to plants found within the same geological range wherein those in the former lists were disembedded, no genera discovered in formations more recent than the CHALK will be included, a circumstance which will explain the occasional interruption in the numbers of the genera. As regards the apparent discrepancy occasioned by so many being ranged under the *Flowering Classes*, we have only to remit the case for elucidation to a better understanding and to more perfect means of identifying the fossil fragments.

EXOGENÆ; OR DICOTYLEDONS.

EUPHORBIACEÆ.

? Genus 11. *Stigmaria*. (Variolaria *Sternb.* Mammillaria *Ad. Bron.* Ficoidites *Artis.*)
5 or 6 species in the Coal formation.
1 species (?) in the Oolite.

CONIFERÆ.

† Wood only known.

Genus 13. *Pinites*. 3 species in the Coal formation.

Genus 14. *Peuce*. 1 species in the Coal formation; others in the Oolite.

Genus 17. *Taxites*. †† Leaves only known.
1 species in the Oolite.

Genus 19. *Voltzia*. †† Branches, leaves, and fruit known.
4 species in the New Red Sandstone.

Genus 21. *Cupressites.* 1 species in idem.

Genus 23. *Thuytes.* †† Branches only known.
4 species (?) in the shistose Oolite.

††† Doubtful Coniferæ.

Genus 24. *Brachyphyllum.* 1 species in the lower Oolite.
Genus 25. *Sphenophyllum.* (Rotularia *Sternb*).
8 species in the Coal formation.

CYCADEÆ.

† Leaves only known.

Genus 26. *Cycadites.* 1 species in the Grey Chalk.
Genus 27. **Zamia.* 15 species in the Lias and Oolitic formations.
Genus 28. *Pterophyllum.* 6 species in Marl and Sandstone of the Lias.
1 species in Quadersandstein.
1 species in the lower Oolite.
Genus 29. *Nilsonia.* 2 species in Sandstone of the Lias.

†† Stems only known.

Genus 30. *Cycadeoideæ.* 2 species in Portland stone.

DICOTYLEDONS OF DOUBTFUL AFFINITY.

?Genus 31. *Phyllotheca.* 1 species in the Coal formation.
Genus 32. *Annularia.* (Bornia *Sternb.*)
6 or 7 species in the Coal formation.

Genus 33. *Asterophyllites* (Bruckmannia *Sternb*).
12 species in the Coal formation.
1 species in Transition beds.

(Obs. This genera is probably an extremely heterogenous assemblage of all fossils with narrow veinless leaves, not united in a cup at their base).

Genus 34. *Bechera.* 1 species in the Coal formation.

ENDOGENÆ; OR MONOCOTYLEDONS.

MARANTACEÆ.

Genus 35. *Cannophyllites.* 1 species in recent bed of Coal.

ASPHODELEÆ.

† Stems only known.

?Genus 36. *Bucklandia.* 1 species in Stonesfield Slate.

Genus 37.	*Clathraria.*	1 species in the Green Sand. (?)
? Genus 38.	*Convallarites.*	†† Leaves only known.
		2 species in the Variegated Sandstone.

PALMÆ.

†† Leaves only known.

Genus 42.	*Flabellaria.*	1 species in the Plastic Clay.
		1 species in the Coal formation.
Genus 44.	*Næggerathia.*	2 species in the Coal measures.
Genus 45.	*Zeugophyllites.*	1 species in the Coal formation.

FLUVIALES.

Genus 47.	*Zosterites.*	4 species in Lower Green Sand.
		1 species in the Lias. (?)

MONOCOTYLEDONS OF DOUBTFUL AFFINITY.

† Stems only known.

Genus 51.	*Sternbergia.*	(Columnaria *Sternb.*)
		3 species in the Coal formation.

†† Leaves only known.

Genus 52.	*Poacites.*	Several species in the Coal formation.

††† Fruits only known.

Genus 54.	*Trigonocarpum.*	5 species in the Coal measures.
Genus 56.	*Musocarpum.*	2 species in idem.

FLOWERING PLANTS OF UNCERTAIN CLASS.

Genus 58.	*Æthophyllum.*	1 species in the New Red Sandstone.
Genus 59.	*Echinostachys.*	1 species in idem.
Genus 60.	*Palæoxyris.*	1 species in the New Red Sandstone.

CELLULARES; OR FLOWERLESS PLANTS.

EQUISETACEÆ.

Genus 61.	**Equisetum.*	2 species in the Lias and Oolite.
		2 species in the Coal formation.
? Genus 62.	*Calamites.*	2 species in Transition beds.
		Several species in the Coal formation.
		4 species in the New Red Sandstone and Coal.

FILICES.

Genus 63.	*Pachypteris.*	2 species in Inferior beds of Oolite.

Genus 64.	*Spenopteris.*	1 species in Sand below the Chalk.
		2 species in the New Red Sandstone.
		5 species in the Oolitic formation.
		28 species in the Coal formation.
Genus 65.	*Cyclopteris.*	4 species in the Coal formation.
		1 species in Transition series.
		1 species in the Oolite.
Genus 66.	*Glossopteris.*	2 species in the Coal measures.
		1 species in the Oolite.
		1 species in the Lias.
Genus 67.	*Neuropteris.*	24 species in the Coal formation.
		3 species in the New Red Sandstone.
		2 species in the Muschelkalk, &c.
Genus 68.	*Odontopteris.*	5 species in the Coal measures.
Genus 69.	*Anomopteris.*	1 species in the New Red Sandstone.
Genus 70.	*Tæniopteris.*	3 species in the Lias and Oolite.
Genus 71.	*Pecopteris.*	60 species in the Coal formation.
		10 species in the Oolite.
		2 species in the Lias.
Genus 72.	*Lonchopteris.*	2 species in the Coal formation.
		1 species in the Green Sands.
Genus 73.	*Clathropteris.*	1 species in the Lias.
Genus 74.	*Schizopteris.*	1 species in the Coal formation.
Genus 75.	*Filicites.*	1 species in New Red Sandstone.
		2 species in Marl of Lias.
Genus 76.	*Caulopteris.*	1 species in the Coal measures.

Lycopodiaceæ.

Genus 77.	*Lycopodites.*	10 species in the Coal formation.
		3 sp. in the Oolite, Lias, and Chalk.
Genus 78.	*Selaginites.*	2 species in the Coal formation.
Genus 79.	*Lepidodendron.*	Several species in idem.
Genus 80.	*Ulodendron.*	2 species in idem.
Genus 81.	*Lepidophyllum.*	5 species in idem.
Genus 82.	*Lepidostrobus.*	5 species in idem.
? Genus 83.	*Cardiocarpon.*	5 species in idem.

Algæ.

Genus 86.	*Confervites.*	2 species in the Chalk Marl.
Genus 87.	*Fucoides.* (Agacites *Schloth*).	
		4 species in Transition rocks.
		7 species in Bituminous Shale.

		3 species in the Oolite.
		11 species in the Chalk.

PLANTS OF UNCERTAIN AFFINITIES.

Genus 88.	*Sigillaria.*	40 species in the Coal formation.
Genus 89.	*Volkmannia.*	3 species in idem.

Notes, referable to the foregoing concentrated lists of fossil vegetable remains, extracted from Professor Buckland's Bridgewater Treatise :—

FILICES, OR FERNS—The most numerous of the Vascular Cryptogamic plants. The circumstances most favourable to their growth are humidity, shade, and heat. In the Coal formation there are about 120 known species of Ferns, forming about a half of the entire known Flora of this formation ; these species represent but a small number of the forms which occur among living Ferns, and nearly all belong to the tribe of Polypodiaceæ, in which tribe are found the greater number of existing arborescent species. The stems of these arborescent Ferns are distinguished by certain peculiarities from those of all *Monocotyledonous* plants.

EQUISETACEÆ—Well known in this climate as the common Horsetail of our swamps and ditches ; reaches from Lapland to the Torrid Zone. Divided (the fossil ones) by Brongniart into *Equiseta* and *Calamites.* The former rare in a fossil state. The latter are characterised by large and simple cylindrical stems, articulated at intervals. Sometimes marked by verticillated branches, and attain to great size. Latitude seems to have had no effect on the size of fossil equisetaceæ. (p. 461).

LEPIDODENDRON—In some points of their structure they have been compared to Conifera ; but in other respects, and in their general appearance, with the exception of their great size, they very much resemble *Licopodiaceæ*, or *Club-moss* tribe. Professor Lindley states that the affinities of *existing* Lycopodiaceæ are intermediate between Ferns and Coniferæ on the one hand, and Ferns and Mosses on the other. They are related to Ferns in the want of several apparatus, and in the

abundance of axilar ducts contained in the axis, to *coniferæ* in the aspect of the stems of some of the larger kinds, and to *mosses* in their whole appearance. The internal structure of their stems is intermediate between *Lycopodiaceæ* and *Conifera.* Lindley and Hutton state, that *Lepidodendra* are, after *Calamites,* the most abundant class of fossils in the Coal formations of the North of England,* occurring from twenty to forty-five feet long. By means of *Lepidodendron* a better passage is established from Flowering to Flowerless Plants than by either *Equisetum* or *Cycas,* or any other genus.

SIGILLARIA—Plants unknown in modern vegetation, and of which the duration seems to have been limited to the epochs of the Transition period, are dispersed throughout the sandstones and shales that accompany the Coal; colossal; generally filled with sand or clay, and are supposed to have been without any transverse dissepments, and hollow throughout. The bark, which alone remains, probably surrounded an axis composed of soft and perishable pulpy matter like living equisetaceæ. . . . M. Brongniart enumerates 42 species of *Sigillaria,* and considers them to have been nearly allied to arborescent *Ferns,* with leaves very small in proportion to the size of the stems, and differently disposed from those of any living *Ferns.*

Lindley and Hutton show strong reasons for considering that *Sigillaria* were Dicotyledonous plants, entirely distinct from Ferns, and different from any plants in the existing system of vegetation.

FAVULARIA, MEGAPHYTON, BOTHRODENDRON, and ULLODENDRON—Same group of fossil plants to which the *Sigillaria* belongs—all exhibiting a similar disposition of *scars arranged in vertical rows.* They are separated into the following five families, distinguished by the form of their stems and their scars:—

1. *Sigillaria.* 2. *Favularia.* 3. *Megaphyton.*
4. *Bothrodendron.* 5. *Ullodendron.*

In the three first genera of this group, the scars appear to have

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* Bridgewater Treatise, p. 483, et seq.

given origin to leaves; in the two latter they indicate the insertion of large cones.

STIGMARIA—An extraordinary family of extinct fossil plants, *stigmaria ficoides*, dome shaped trunk or stem, 3 or 4 feet diameter. Both its surfaces slightly corrugated, and covered with indistinct circular spots, many horizontal branches varying from 9 to 15, and some of them supposed to have been from 20 to 30 feet long; their leaves have been traced to the length of 3 feet, and have been said to be much longer; the branches are covered with spirally disposed tubercules, resembling the papillæ at the base of the spines of *Echini*; and from each tubercule there proceeded a cylindrical and probably a succulent leaf. The form of the trunk and branches show that they could not have risen up into the air; but must either have trailed on the ground or floated in water.

ASTEROPHYLLITES—So called from the stellated disposition of the leaves round the branches, are still more obscure in their nature than the foregoing, and no traces of them are found among existing vegetables, nor in any strata more recent than the Carboniferous series, and many years may elapse before they are understood."

Conclusion respecting the Plants of the Coal Measures.

"The plants which have contributed most largely to the highly interesting and important formation of the Coal, are referable principally to the genera *Calamites*, *Ferns*, *Lycopodiaceæ*, *Sigillaria*, and *Stigmariæ*. These materials have been collected chiefly from the carboniferous strata of Europe. The same kind of fossil plants are found in the coal mines of North America, and we have reason to believe that similar remains occur in Coal formations of the same epoch under very different latitudes, and in very different quarters of the globe, *e. g.*, in India and New Holland, in Melville Island and Baffin's Bay.

"The most striking conclusion to which the present state of our knowledge has led, respecting the vegetables which gave origin to coal, are—1st. That a large proportion of these plants were *vascular cryptogamiæ*, and especially *Ferns*; 2dly. That among the *Cryptogamic* plants, the *Equisetaceæ* attained a gigantic size; 3dly. That *Dicotyledonous* plants, which compose nearly two-thirds of living

vegetables, formed but a small portion of the Flora of these early periods; 4thly. That although many extinct genera and certain families have no living representatives, and even ceased to exist after the deposition of the Coal formation, yet they are connected with modern vegetables by common principles of structure, and by details of organization which show them all to be parts of one grand and consistent and harmonious design."*

Sir Henry de la Beche, in his *Manual of Geology*, when treating of the fossil flora, especially those found in the Coal measures, expresses himself thus:—

"We have reason to conclude, that in Poland, Western Germany, Northern France, Belgium, and the British Isles, there were some common causes in operation at the same epoch, producing the envelopment of a great abundance of terrestrial vegetables, of a nature which could not, from the want of the necessary heat, now flourish in the same latitudes. . . . . . The vegetable remains are often of considerable size. M. Brongniart observes, that stems are found in the planes of the strata more than 50 or 60 feet long; and that they may be traced in some of the galleries of the Continental coal mines for more than 40 feet without observing their natural extremity. . . . . Respecting the general character of the vegetation of that period, M. Brongniart observes, that it is remarkable 1st for the considerable proportion of the vascular cryptogamic plants, such as *Equisetaceæ*, *Filices*, *Marsilaceæ*, and *Licopodiaceæ*; and 2nd for the great development of the vegetables of this class, so that they have attained a magnitude far beyond those of the same class now existing, thus proving that circumstances were particularly favourable to their production during the period under consideration, ... indeed, he concludes, with much apparent probability, that the climates in which the coal plants existed were even warmer than those of our equinoxial regions."†

"When we examine," says MM. de Candolle and Sprengel, "the remains of the primeval world, we find the first traces of vegetable impressions in the slate formations. These remains of the former vegetable world belong almost entirely to the lower families: they consist, for the most part, of *Grasses*, *Reeds*, *Palms*, and *Ferns*, the latter, however, being almost always destitute of fruit. But

* Professor Buckland's Bridgewater Treatise, pp. 479—481.

† Manual of Geology, pp. 441—447, 2nd Edition, London, 1832.

ALTHOUGH THESE FORMS CANNOT BE REFERRED TO ANY ONE OF THE SPECIES WHICH ARE AT PRESENT KNOWN, they have yet so much the appearance of tropical productions, that we are forced to admit a very high degree of heat at the surface of the earth during its former state, which heat must at that time have been diffused over all the zones, because we find the same productions in the slate formation of all parts of the earth.* In order to explain this, it has been supposed, that the plane of the ecliptic, during the former state of the globe, was completely different in its position, and that, consequently, our planet had then another situation with respect to the Sun. But Bode, the worthy veteran of Prussian astronomers, has shown, that the plane of the ecliptic has been for 65,000 years (!!) between the 20th and 27th degree; and that at present it is about 23 minutes less, and consequently, the former solution must be entirely abandoned."†

The following corroborating extracts are of peculiar interest, as they mark Mr. Turner's acquiescence in, and approval of, the information given by those from whom he quotes.

"That vegetable remains abound in that series of rocks and masses which constitute the Coal formations is universally agreed. Plants were therefore in being before the coal strata originated; and it is also now the general sentiment, that our coals are a transmutation of vegetable matter into that state—an extended mass of mineral peat or turf."‡

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* It seems, indeed, that all the carbonaceous matter of the more ancient Slate formation ought to be considered as the oldest remains of plants which had been growing, but which had been stopped in their progress; and that all calcareous matter ought to be considered as the remains of a begun, but suppressed creation of animal bodies. In what manner mineral substances are formed from corrupting vegetables, we perceive from the production of iron pyrites in our peat mosses, where it is found in layers under the thin, broad, reed leaves, after they have become putrid.

† Elements of the Phil. of Plants, Edin. Trans. pp. 276, 277.

‡ M. Marcel de Serres considers the remains of the first period of vegetation to have formed the Coal beds. "They are remarkable for their little variety; for the simplicity of their organization; and for the largeness of their size. They seem to be referable to two chief classes of the vegetable kingdom—to the vascular cryptogamics, as the ferns, the horse-tails, and the club-moss tribe; and to the monocotyledons, but of these only a few that resemble palms and arborescent plants."—*Geognosie*, p. 22.

In a note pertaining to the division of his work Mr. Turner gives the following interesting information relative to the fossil vegetable remains:—

"M. Al. Brongniart's tableau, No. 17, gives a long list of them, of which the substance is—'No kind of marine plants; all land ones; Equisetaceæ, Calamites 12 species. Of Ferns, 21 kinds of Sphænopteris; 2 kinds of Cyclopteris; 11 of Nevropteris; 1 Glossoptera; 46 species of Pecopteris; a Lonchopteris; 5 kinds of Odontopteris; 41 of Sigillaria. Of Marsileaceæ or the Pepperwort tribe 7 species. Of the Lycopodiaceæ 10 species; 2 of Selaginites; and 34 of Lepidodendron; 5 of Lepidophyllum; 4 of Lepidostrobus; 5 of Cardiocarpum; and 8 of Stigmaria; 3 of Palms; a Canna, and 14 species of Monocotyledons.'"*

Mr. Lyell says—

"Between two and three hundred species of plants are now enumerated as belonging to the carboniferous era, and of these a very few only are Dicotyledonous."†

Professor Henslow observes—

"The history of vegetation could not be completed without some enquiry respecting those plants which existed on the earth in its primeval state, during the extended geological epochs which elapsed before the establishment of the present order of things. Traces of this ancient vegetation are very abundant in certain strata, but more especially in the '*Coal measures*,' the important mineral combustible obtained from them being nothing else than vegetable matter in an altered and fossilized state. In general, we do not find the remains of plants so perfectly preserved as the skeletons of vertebrate animals, or the testaceous coverings of mollusca. It is also rare to meet with those parts (the flower and seeds) upon which the distinction of species and their classification chiefly depend, but still the fragments which remain often possess very great beauty; and many specimens of wood are so exactly preserved, that their tissue may be distinguished under a microscope as completely as in recent species. As it is principally from these fragments of stems, and the impressions of leaves, that any comparison between the ancient and

* Turner's Sacred History, pp. 179—181.

† Principles of Geology, vol. i. p. 169.

present flora of our planet must be instituted, it will be evident that such data must generally be far too imperfect to admit of any accurate determination of specific differences, though they may afford us sufficient materials for ascertaining several truths of high interest. The class, order, sometimes the precise genus, may be ascertained to which a fossil vegetable belongs, even though we possess only a small fragment of the plant. More frequently, these fossils bear an analogy to some recent genera, which they closely resemble, but to which they cannot be accurately referred. In such cases this resemblance is indicated by referring them provisionally to a genus whose name is a modification of the recent genus: thus '*Lycopodites*' is a genus of fossil plants allied to '*Lycopodium*,' but too imperfectly known to have its characters fully pointed out.

"It was soon remarked, when the study of fossil vegetables began to attract the attention of botanists, that those from the coal measures were distinct from the plants now existing on the surface of the earth, and that they more nearly resembled the species of tropical climates than such as grew in the temperate zones. Subsequent researches have shown that the species embedded in different strata likewise differ from each other, and that on the whole there are about fourteen distinct geological formations in which traces of vegetables occur. According to Mons. Brongniart they first appear in the schists and limestones below the coal. These contain a few *Cryptogamic* species (about thirteen), of which four are marine algæ, and the rest ferns, or the allied orders. In the coal itself above 300 distinct species have been recognized, among which those of the higher tribes of *cryptogamic* plants are the most abundant, amounting to about two-thirds of the whole. Many of them are arborescent, and parts of their trunks are found standing vertically in the spots where they grew. There are no marine plants in this formation. A few palms and graminæ are the chief Monocotyledons; and there are several Dicotyledons which have been considered analogous to Apocynæ, Euphorbaciæ, Cactæ, Coniferæ, &c. . . . . . The great predominance and size of arborescent ferns and other tribes of Ductulozæ constitute the main feature of the formation.

"Above the Coal we arrive at the New Red Sandstone; in some of the formations subordinate to this series a few species of fossil plants occur. In the Oolitic series they become more abundant, and some beds are remarkably characterised by the prevalence of the genus *Zamia*, together with some *Coniferæ*, *Liliaceæ*, and many *Ferns*, the latter being very distinct from those in the former for-

mations. In the Green Sandstone and Chalk few species have been hitherto found, and these are almost all marine. Among the Tertiary strata (or those above the Chalk) the *Dicotyledons* begin to prevail to a far greater extent than they did before, and the plants are entirely different, including terrestrial lacustrine, and marine species. Several fruits are referable to existing genera, as Acer, Inglans, Salix, Ulmus, Cocos, Pinus, &c.

"It is remarkable that scarcely any species has been found in more than one distinct formation, and none has occurred in any two which are separated by a long epoch. Hence it appears to be a natural conclusion, that there have been successive destructions and creations of distinct species. . . . . .

"Judging from analogy, from the characters, and relative proportions of the species in different classes, the temperature of those parts in which the plants of the first period were growing, must have been both hotter and moister than the climate in any part of the earth at present. It has been plausibly conjectured that the atmosphere was more charged with carbonic acid at those early periods of our planet's history, when gigantic species of cryptogamic plants formed the main feature of its vegetation. . . . . . Since the fossil plants, which have been found in the arctic regions, are analogous to those which now grow in tropical islands, it seems likely, that not only must they have enjoyed a higher temperature, but also a more equable diffusion of light than those regions now possess."*

We earnestly trust that these copious extracts and lists, which we have given even at the risk of being thought tiresomely profuse, will be considered sufficient to prove the existence of vegetable remains in the older stratified masses, and fully to have exhibited their character; should, however, further evidence still be wished for, reference may be made to the geological works mentioned in the course of this Treatise, from which these extracts have been taken, where all required information will be found.

No explanation beyond the notes and surmises mentioned in the course of these proofs can be given for the apparent anomaly caused by the occasional presence of some *Monocotyledons* and of a few *Dicotyledons* amongst the fossil vegetable remains. Vestiges of each may have more recently sunk down

* Botany in Cab. Cyc. pp. 310—313. Also the authority for 36th Theorem.

into fissures and crevices, and there become fossil, appearing to belong to geological periods much more remote than those in which they grew; while we may with confidence avail ourselves of what Messrs. Lindley and Hutton and Prof. Henslow assert, which forms the basis of the *hundred and twenty-seventh* Theorem,* respecting the difficulty of comparing the mutilated fossil vestiges with their recent analogies, while we rely with composure on a more thorough examination for the elucidation of the difficulty; feeling thoroughly convinced that no *Monocotyledonous* or *Dicotyledonous* plant, properly so called, which required floral envelopes for the development of its seed, did, or could possibly have existed previous to the light, the atmospheric air, and the elevation of the dry land above the waters: while, as regards the perplexities attendant on the classifications of *fossil* plants, to which Professor Henslow so clearly alludes in his work, they could not possibly be described in more clear or forcible language than that which has been employed by those joint labourers who, more than any others, have been inconvenienced by them.

"Unfortunately," say Messrs. Lindley and Hutton, in the preface to their great work, "Fossil Botany is beset with difficulties of a peculiar character; the materials that an enquirer has to work upon are not only disfigured by those accidents to which all fossil remains are exposed, but the parts found are those which in recent vegetation would be considered of the smallest degree of importance. There is, in most cases, an almost total want of that evidence by which a botanist is guided in the examination of recent specimens, and not only the *total destruction of the parts of fructification*, and of the internal organization of the stem, but what contributes more to the perplexity of the subject, a frequent separation of one part from another; of leaves from branches, of branches from trunk; and, if fructification be present, the separation of it even from the parts of the plant on which it grew, so that no man can tell how to collect the fragments that remain into a perfect whole; for, it must be remarked, that it is not in botany as in zoology, where a skilful anatomist has no difficulty in combining the scattered bones of a broken skeleton.

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* To which please refer.

"In botany, on the contrary, the component parts of both foliage and fructification are often so much alike in outline, which is all that the fossil botanist can judge from, as to indicate almost nothing when separated from each other, and from the axis to which they appertain. It is only by the various combinations of these parts that the *genera* and *species* of plants are to be recognized, and it is precisely these combinations that in *fossils* are destroyed."*

Should any of our readers be disposed hastily to conclude that these assertions ought to invalidate the *whole* of the evidence sought to be adduced by the findings and announcements of *Fossil Botanists*; labouring, as they do, under such disadvantages, and so much exposed to the possibility of giving a wrong decision when classing the petrified fragmental specimens which time and many casualties have spared for their inspection; we would beg to remind any such, that besides the circumstance of ferns and some allied cryptogamic plants being those whose remains have best resisted the lapse of ages, and are found most perfect and entire, the *negative* character of the proof which most corroborates our position enables us in this case, to avail ourselves, alike, of what exists and what does *not*. Guided by the announcements of Scripture, we did not expect that there should have been found either true "*seed of herbs*," or true "*fruit of trees with seeds in them*," although we counted on the discovery of reproductive processes of some kind or other. Consequently, the absence of the two former—the phanogamous means of propagation—so far from militating against our argument, has a tendency all the other way; and as such we adopt and recommend it to our readers.

Considering this a convenient resting-place, from whence to take a brief review of the ground we have gone over in this and the previous chapter, which has unavoidably been much broken and uneven, we shall briefly recapitulate what has been done, not only in order to refresh the memory, but, likewise, the more effectually to apply what we have acquired to what has yet to be accomplished.

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* Fossil Botany, by Lindley and Hutton. See also p. xxvii. of same volume, and p. vi. of part I. of volume II.

By an enquiry into the characteristics of the *first* great CLASS of plants, the *Dicotyledons* or *Exogenæ*, we found that they corresponded so closely to the group mentioned in Scripture which "*bear fruit having seed in itself*," that they completely filled up that division of the Vegetable Kingdom. By a similar investigation into the nature and structure of the *second* class, called *Monocotyledons* or *Endogenæ*, we discovered that, being "*herbs bearing seeds*" merely, they, in like manner, completed the group designated in Genesis "*the herb yielding seed*." But as these two *classes* do not, however, exhaust the whole of the known plants, but leave to be accounted for the *flowerless, seedless* plants, called *Cryptogames*, of which neither allusion to, nor direct mention is made in Genesis, we were forced to conjecture, with due allowance for the difficulty of arranging them, and the consequent imperfection of their classification, that the plants of this description, or such as shall be declared *flowerless, seedless*, or *fruitless* had been willed into existence by previous fiats of the Creator during the period of the earth's non-rotation, and at those particular junctures in the due development of the plan of Creation when their agency was most required, while as yet there was no sun-light, and the Earth, being without rotation, was immersed in a universal ocean. On this point we were particularly desirous to explain the probable consequences of the indistinct line of separation between plants possessing perfect seeds and those having no claim to such, when investigations are being made amongst the orders of *Cryptogamia*, where these characteristics are involved in obscurity and uncertainty; and where, moreover, only vestiges of fossil plants form the objects of examination. Confirmed, however, in the belief that the *flowerless, seedless, fruitless* plants were *not* formed on the third day of the Mosaic week, but had been previously brought into existence by GOD the Creator of all things, we next directed our attention to the character of the fossil remains themselves, which we presented to the reader in abstract consolidated lists, with the additional evidence of the explanations and notes of those writers who have most dedicated themselves to the investigation of these objects of natural history, and the result was that a direct corrobo-

rative testimony was afforded as to the soundness of the leading views adopted by us. The vast majority of the fossil plants being unconsciously declared—by men who never anticipated such an application of their evidence—to belong chiefly to the *cryptogamous* class of plants.

And, on the whole, we consider it to be hardly possible to meet with greater success in any similar enquiry than that which we have experienced in this branch of our argument. The conviction we entertained of the truth of Scripture and of the Omniscience of its Author—the Creator also of the objects of our research—led us to conclude, when applied to the experience of botanists *that a grand division of the vegetable kingdom had been created before the period of rotation*, and were of a description corresponding to the then condition of the world. On further research we found the geological botanists of our present era busy with extensive repositories of fossil plants which they had dug up from the bowels of the Earth, and which—without any reference to the source of our information—they had described and classed as correctly as the peculiar circumstances attending their discovery would permit. And when we compared the vestiges thus discovered with those whose origin we were in quest of, we found the two to correspond in almost every particular; so much so that wherein the opinion of these intelligent botanists agree—and this is happily the case with respect to the great majority of the plants—they concur in referring them to those *Orders* of imperfect plants whose formation is not recorded by the Sacred Historian: and wherein any are inclined to refer them to higher classes or orders, there is not unfrequently a difference of opinion amongst them; the plurality of votes seeming to be in favour of the disputed fossils having belonged to the flowerless Cryptogames.

Having thus, with much care and success, surmounted the prefatory part of our labours in this section, we must now direct the attention for a short time *to the adaptation of those imperfect, flowerless plants to the condition of our planet at a period when it was without light, without diurnal rotation, and circumbounded by an atmosphereless ocean.* In doing this, we shall have to pursue a path somewhat similar to that

which, in a corresponding part of the preceding section, we had to tread, when shewing the close adaptation of the animals of the ancient world to the state of the Creation during their occupancy of the earth; and, to a certain extent, the constraint we are thus placed under, will add another, and no mean proof, to the many already adduced, of the justness of our views; similar influential causes having produced, in either case, analogous results.

We shall commence, therefore, by a detailed investigation into the nature and functions of the respiratory organs of plants, which principally consist of their green parts—the *leaves*.

The writer on Botany, in the *Library of Useful Knowledge* says—

"The stem of a plant is clothed with what are collectively called its appendages, or appendages of the axis, consisting of leaves and their modifications, and of flowers with their parts. The former, taken with the stem itself, are called *organs of vegetation*, or nutrition; the latter of *fructification* or *reproduction*.

"*Leaves* are usually those expansions of the bark into which slender processes of the wood and fibre insinuate themselves, and within which, after shooting beyond the surface of the stem, they expand and branch in every direction, filling the whole of the pulpy substance with a net-work of tough and stiff fibres, which serve to sustain the mass of the leaf. The *leaf* is therefore in intimate connection with both parts; with the bark on the one hand, and with the wood on the other; consisting of the portions of the systems of these two important parts intimately intermingled, but each capable of acting singly as well as in concert. The pulpy substance which expands from the surface of the bark and forms the principal part of the leaf is technically named the *parenchyma*, and the fibres that maintain it *veins*. The latter are also frequently called *nerves* or *nervures* in botanical language, although improperly; for they are merely channels through which fluids are impelled, and they have no connection, as far as we know, with any action resembling the nervous system of animals. . . . . .

"The universal presence of leaves upon all plants; their highly complicated structure; the intimate connexion which it has been shown they maintain between the systems of the wood and the bark; their extremely high development in many cases; and their multiplied

variety of forms, all lead to the opinion that they are organs of the most essential importance. This is confirmed by their internal structure, independently of experiment.

"Most leaves are not thicker than a piece of paper or parchment, and appear to the naked eye as nothing more than a thin green plate, so that an ordinary observer would never suspect that their internal structure, which no eye, unassisted by glasses, can investigate, was one of the most complicated and highly organized character; and yet there is no part among those with which plants are furnished which is more complex. It is necessary, indeed, that it should be so, in order to be enabled to perform the important functions of digestion, respiration, and perspiration, for which it is destined. . . . . .

"The anatomical structure of the leaf appears distinctly connected with its functions of respiration and evaporation. That side of the leaf which is next the sun being most exposed to heat, the cylindrical bladders that form it are placed with their narrow ends next the cuticle, by which means they not only each present the smallest evaporating surface, but are so circumstanced with respect to each other, as to be able with the least difficulty to absorb fluid from each other as they empty. The bladders next the lower surface not being exposed to the same kind of external influence, do not require the same kind of internal adjustment of their parts, but are arranged with wide intervals between them, which communicate with the chambers below the numerous breathing pores of the lower surface. Here, then, the functions of respiration are best performed: each bladder, on the one hand, exposes the greatest possible extent of surface to the action of the oxygen or carbonic acid that may be received by the breathing pores; and has, on the other, the greatest possible power of parting; firstly, with the oxygen which results from the decomposition of the carbonic acid in these vegetable stomata, and secondly, with the superfluous water which is not evaporated by the upper surface through the cuticle. It will be observed that in the water-lily, in which the most cavernous part of the parenchyma is next the upper surface, the leaf floats with its lower face upon the water; respiration, consequently, cannot take place at the under surface, and the function, of necessity, is transferred to the upper, where the stomata all are.

"From these statements it is to be inferred that leaves are a sort of pneumatic apparatus, of a highly curious and elaborate structure; and that the variations which occur in their internal organization

are beautiful adaptations of the parenchyma to the particular circumstances under which the leaves themselves are placed.

" Light, heat, and water, are the external agents which, acting upon the vital principle, set all the machinery of vegetation in motion. No one of these causes will, by itself, produce the effect, although their continuation be of the most powerful kind.

" Light, as we shall hereafter see, causes the decomposition of carbonic acid, fixing the carbon in the interior of the tissue, and thus solidifying the more delicate parts, or altering the chemical nature of others. It is the grand cause of the varied colours of vegetation, and may be considered as being, in part, what produces a motion of the fluids. In its absence plants are weak, sickly, and soon perish.

" Heat, by drying the atmosphere, produces evaporation, which is one of the great means by which the crude fluids become inspissated and altered in their nature ; it causes the expansion of the gases which plants contain, distends their tissue, and renders the latter more capable of performing its contractile and hygrometrical functions.

" Water relaxes all the parts, dissolves the soluble matters which are laid up in a plant in a state of torpidity, and softens the tissue till it is capable of receiving the influence of temperature. It is, moreover, the medium by which the nutritious principles that are deposited in the earth are absorbed by the roots, and conveyed from one part of the system to another.

" To sum up in a few words all that has thus far been stated, it is *light, heat, and water, acting in concert upon the irritable membrane, which enable plants, by virtue of their extensibility, elasticity, and hygrometrical powers, to perform the phenomena of contraction and endosmose, by means of which they absorb and digest their food, circulate their fluids, develope their organs, increase in size, and reproduce themselves.*"*

" Under the name of respiration, we shall include all that is connected with the inhaling and giving off of gaseous matter. This function is chiefly connected with the absorption of oxygen and carbonic acid, and their expiration. By a vast number of experiments chemists have determined that the green parts of plants placed in the sun absorb carbonic acid from the atmosphere, and decompose it, giving back the oxygen ; and that at night they absorb oxygen from the atmosphere, giving off carbonic acid : it is also probable

* See 120th Theorem.

that they part with a small quantity of carbonic acid during the day . . . . . These conditions are necessary in order to secure the disengagement of oxygen by leaves: firstly, the parts must be green; secondly, they must be exposed to the direct action of the solar rays; and thirdly, there must be carbonic acid in the water.

"The circumstance that green parts alone, with a few exceptions, are capable of giving off oxygen, sufficiently proves that it cannot result from what atmospheric air may adhere to the leaves under experiment. . . . . . That it is, in fact, a vital action is proved by dead leaves, still green, having no power of emitting gaseous matter until they begin to decompose.

"It is not sufficient to place leaves in bright light to procure the emission of oxygen by their leaves in water; it must be under the direct rays of the sun. De Candolle found the purest day-light, the brightest lamplight, insufficient to produce the phenomenon; a very curious result when we consider how large a part of vegetation is seldom exposed directly to the solar rays. Of course nothing like emission of oxygen would occur at night.

"From this and many other considerations, we are forced to conclude that oxygen is absorbed by plants at night. This gas does not, however, remain in the system of the plant in an elastic state, for neither the air-pump nor heat will disengage it; but it appears to incorporate itself with the tissue, since solar light readily disengages it. The inference therefore is, that it is absorbed at night, and combines with the carbon already existing, forming carbonic acid, and that the latter is decomposed by the sun, as has before been shown. . . . . . From whence, it may be enquired, is the large quantity of carbonic acid obtained which is thus necessary to the support of plants? Certainly not from the atmosphere alone, for it does not usually contain one part in a thousand of carbonic acid. There can be no doubt that this gas is supplied principally by the Earth, in which it exists in great quantity; that a part is obtained from the atmosphere; and that a certain other portion results from the combination of the oxygen of the atmosphere with the carbon of vegetation; and it would seem as if a repeated decomposition and recomposition of carbonic acid was the principal phenomenon in respiration.* . . . . . Hence it appears that while animals vitiate the atmosphere by respiring carbonic acid, plants purify it by absorbing it. It may be said, indeed, that they also deteriorate it, by

* See 124th Theorem.

abstracting its oxygen ; but it is to be remembered that if they inhale it at night, they return it in the day-time. . . . . . .

"What we have now seen of the action of the leaves and green parts of plants will enable us to appreciate the adaptation of their internal structure to perform their functions. We have found them to consist of a number of little cells or bladders, so loosely cohering that the air has room for free circulation between them ; and that, by the way in which they are arranged, they present the greatest possible surface to the action of the atmosphere. Although they are enclosed in a thick cuticle, yet they are provided with openings through it, called stomates, by means of which free admission for air is secured, and through which it may be expelled again with facility when they are submersed, and are, consequently, neither exposed to irregularities of temperature nor of dryness in the air. They have no occasion for either cuticle or stomates ; for the water in which they float carries the air dissolved in it to every part ; and consequently, submersed plants have neither. It is true that Mons. de Candolle entertains doubts whether the stomates are not rather organs of evaporation ; but when we consider the relation they bear to the air cavities in leaves we can scarcely doubt that they are really respiratory organs ; nor does it appear clear why they should not, in fact, perform the functions both of perspiration and respiration. If we hold a leaf of Laurustinus over a candle, so as to heat the air contained in it without burning the leaf itself, the air will be expelled through the stomates with such force as to extinguish the flame."*

In corroboration of the foregoing, we give the following quotations from Professor Henslow's work on Botany :—

"The first actual change produced in the sap is effected by a process analogous to animal respiration. The air is inhaled by the leaf and the fresh surfaces of other parts of the plant, and its oxygen then unites with the carbonaceous matters contained in the sap, and the result is carbonic acid. The greater part of this gas is then held in solution by the sap ; and the whole, or very nearly, azote which has separated from the oxygen is exhaled. Besides the carbonic acid thus formed by the plant itself, the trifling proportion everywhere found in the atmosphere is also inhaled ; and a still larger

* Botany, in Library of Useful Knowledge, pp. 21, 28—31, 79, 80, 87—90.

quantity is introduced in the water absorbed by the spongioles. Hence it appears that a three-fold provision is made for maintaining a supply of this necessary ingredient.* So long as plants remain in the dark, no fresh change takes place in this condition of things; the carbonic acid is retained, but is not fixed in the form of an organic compound. This further result requires the additional stimulus of light, and then the decomposition of the carbonic acid is effected; the carbon becomes fixed under the form of an organizable compound, and all, or nearly all, the oxygen with which it is united is exhaled into the atmosphere. So long, then, as plants continue to vegetate in the dark they tend to vitiate the atmosphere by abstracting its oxygen, and also by the emission of some portion of the carbonic acid which they generate; but when they are exposed to the light, they not only restore the oxygen which they had previously abstracted from the atmosphere, but also give out another portion of this gas which they set free by the decomposition of the carbonic acid contained in the air, as well as that which was in the water imbibed by the spongioles. In animal respiration, the carbonic acid is immediately expelled from the lungs as soon as it is formed, and the function is then considered complete; and perhaps it would be more logical to divide the function of vegetable respiration into two processes, one of which should comprise the formation, and the other the decomposition of carbonic acid. . . . . . .

"When all these parts of plants which are capable of assuming a green tint, but more especially the leaves, receive the stimulus of light, they immediately decompose the carbonic acid contained in the sap. The result of this action is the retention of the carbon, and the expiration of the greater part of the oxygen into the surrounding atmosphere. The most obvious effect produced by this fixation of carbon is the appearance of that green colour which we find in nearly all leaves and in some other organs. . . . . . The fixation of the carbon by plants appears to be the first step in that elaborate process by which brute matter is converted into an organisable compound, that is to say, into a material capable of being afterwards assimilated into the substance of an organised body. Many effects popularly ascribed to the action of air, are, in fact, due to the agency of light. Thus, trees which grow in elevated or in isolated situations are more vigorous than others of the same species which grow in forests or in shady places; and those on the

* 124th Theorem.

skirts of a wood are finer than those in the interior. . . . . . The loss of light in stoves and greenhouses, by diminishing the effects of exhalation, renders plants more liable to be frozen than others of the same description which are growing in the open air.

"Although the decomposition of carbonic acid by the green parts of plants is perpetually carried on under the stimulus of diffused light, and its effects may even be rendered apparent by the action of lamp-light, which gives a slight tinge of green to plants when grown in a cellar, yet in these cases the process is carried on too slowly to allow of our collecting the oxygen which is set free. But when plants are placed in the direct rays of the sun, the action is so much more rapid, that the oxygen may then be collected in sufficient quantity to produce a striking result.

"A certain portion of free oxygen is necessary for the formation of the carbonic acid generated by the process of respiration; but when this carbonic acid is decomposed and the carbon fixed, the same oxygen which is set free will serve again for a fresh formation of carbonic acid so long as there remains any carbonaceous materials in the sap. This may assist us in explaining an interesting fact described in the *Gardeners' Magazine*, vol. x. p. 208. It is there stated that many plants, especially ferns, have been readily grown in the smoky atmosphere of London, by placing them in boxes furnished with glass coverings hermetically sealed. In this state they have lived and increased in size during several years without any immediate communication with the atmosphere.*

The following succinct corroborative evidence is from the recent work of a philosophical Meteorologist, and we give it with much pleasure :—

"This leads us to refer to a speculation of M. Adolphe Brongniart, upon the formation of those carboniferous beds which are so widely distributed over our globe, and without which civilization would not have rapidly advanced. To this geologist it has occurred that, during that era of our earth's history, the atmosphere was much more largely charged with carbonic acid gas than now or previously.

During that era there seems to have been an ascendancy in the vegetable over the animal kingdom; for, while immense numbers of

* Botany, in Cab. Cyc. pp. 186—194.

trees and arborescent ferns and smaller plants existed, scarcely a vestige of land animals is to be found. If we suppose that during that period there was a larger proportion of carbonic acid in the air than now, it would be most favourable to vegetable life, while the excess would be detrimental to that of animal existence.

"No sooner were those vast coal fields deposited, than we find a manifestation of animal life, and, finally, its predominance. We find much luxuriant vegetation in the presence of those waters which are richly charged with carbonic acid gas."*

These explanations of the phenomena attending the organization, the respiration, and the evaporation of perfect flowering plants, together with the manner in which they form and decompose carbonic acid, are amply sufficient to shew that sunlight and atmospheric air are indispensably requisite for effecting those important functions of the vegetable economy; and consequently, it is quite unnecessary to prove that none of the flowering plants requiring these essential elements could have existed previously to the formation of the light and of the atmosphere, and are, therefore, to be considered as not having, in any way whatever, contributed to those widely-extended and important labours performed by the agency of plants during the protracted period of non-rotation. They may, we think, after a few further explanations, be eliminated entirely from our future argument. They did not then exist.

But, in order to leave no lingering doubt unremoved, let us next enquire whether they could have fulfilled the end of their being—their reproduction—had they been submerged in water. We shall first recapitulate the *hundred and eighteenth* Theorem: *That all the phenomena attending the flowering of plants and the dihescense of the various receptacles which are instrumental in the fertilization and maturation of the* SEED *and* FRUIT, *and the dissemination of the former, fully attest the absolute necessity of these* COMPLICATED OPERATIONS BEING CONDUCTED IN ATMOSPHERIC AIR. *The presence of much moisture being prejudicial to the peculiar development of the pollen;* and, in continuation, we shall give a few corro-

* Introduction to Meteorology, by Dr. Thomson, pp. 13, 14.

borative extracts, the Theorem itself being almost sufficiently conclusive :—

" It is further essential," says Prof. Henslow, " that the pollen should be protected from the influence of moisture ; and, consequently, we find that aquatics, as the water lily (*Nymphæalba*), elongate their flower stalks until the blossoms float upon the surface of the water. In the water-soldier (*Stratiotes Aloides*), water-violet (*Hottonia Palustus*), and others, the entire plants float to the surface of the water during the period of flowering, but live submerged at other times. In the *Zostera Marina* the flowers are arranged within a cavity filled with air ; and thus, although they are developed beneath the surface, they are protected from the immediate contact of the water.

" If ripe pollen be placed in a tub of water and examined under a miscroscope, in a few seconds it will be seen to dilate, burst, and violently expel a cloud of minute granules. These granules are still contained within the inner membrane of the pollen grain protruded through the ruptured outer membrane, but which is difficult to be observed on account of its extreme tenuity. It thus forms a sort of rude sack, termed " a pollen tube," and contains a liquid, the ' fovilla,' in which are dispersed a number of very minute ' pollen granules.' . . . . . In consequence of the effect thus produced on pollen by water, it is liable to injury in rainy seasons, and the fertility of the seed is often impaired. . . . . .

" The salt of sea water produces an injurious effect upon the seeds of plants, and completely destroys the vitality of those which are long subjected to its influence."*

"When the flower unfolds," observes the writer on Botany in the *Library of Useful Knowledge*, " the anther is a tolerably solid, moist body, filled with moist pollen. The grains of the latter contain a fluid more dense than the tissue that forms a covering for them, and rapidly absorbs its moisture from the anther case. As soon as this has happened to any great extent, the tissue of the anther case contracts, and at first rends into grated cells of various forms ; as the dryness is increased, these latter contract still farther, and exercising a general power over the whole surface of the lining would, in the end, be rent into still finer portions, if it were not for the

* Botany, in Cab. Cyc. pp. 263, 266, 303.

slight degree of cohesion which exists between the valves of the anther at the sutural line."*

These quotations, which we have considered it necessary to give as conclusively as possible, sufficiently prove that atmospheric air is not more essential to the entire phenomena connected with the development and reproduction of the *Monocotyledonous* and *Dicotyledonous* plants than that an undue degree of moisture is prejudicial to these functions: consequently, deprivation of the light and atmospheric air and submersion in water would have been altogether destructive of those important functions in *flowering* plants. They could not, in such a condition, have existed. But, on the other hand, as the most perfect wisdom pervades the whole design of Creation, it is but just to conclude that an adequate motive existed for the adoption of whatever principle may be evidently traceable in it. There is a principle peculiarly observable in the formation of the Vegetable Kingdom. The two great classes of plants which were called into existence *after* the formation of the light, the atmosphere, and the "dry land," were *flowering* plants, whose submersion in water, as we have just seen, would have been wholly destructive of their propagation; while those which existed before were *flowerless* plants possessing neither stamen, stigma, nor pollen, radicle nor plumule; therefore it is allowable to conclude that light or atmospheric air were not indispensably essential, nor was water inimical to the maturation, or to the subsequent development and germination of their reproductive bodies, whether these were sporules, cones, or dot-like bodies.

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* Library of Useful Knowledge, p. 109.

SECTION III.

THE VEGETABLE ORGANISMS OF THE NON-ROTATORY PERIOD.

CHAPTER VI.

The assumed condition of the primitive vegetation compared with Botanical descriptions of Cryptogamous plants. Characters and habitats of these given in detail, and found to coincide with the supposed state of the submerged vegetation of the anti-rotatory period. Motives for supposing that there was only one general elevation of the terraine portion of the earth. The absence, in lists of fossil flora, of certain orders of Acotyledonous plants accounted for. Capability of plants growing in the waters of the primeval ocean, although this held in solution saline materials.

The important results to which we came at the conclusion of the preceding chapter will be greatly confirmed should it be found that what, in it, was deduced from reasoning *a priori*, agrees with that which experimental botanists declare to prevail amongst those interesting objects of the vegetable kingdom which are now under our consideration; for, if those two branches agree we can scarcely any longer entertain a doubt. According to the foregoing consolidated lists, the plants found in the stratified masses which have been identified and classed consist of 1. Algæ. 2. Filices. 3. Characeæ. 4. Lycopodiaceæ. 5. Marsiliaceæ. 6. Equisetaceæ. 7. Naiades or Fluviales. 8. Cycadeæ. 9. Euphorbiaceæ, with a few Coniferæ and Palmæ, some Cannæ, and others still uncertain as to class and genera, which consequently cannot be taken into account. But to those which have been identified we shall affix, in the order

in which they stand, a succinct account of their usual *characteristics* and *habitats.*

"ACOTYLEDONS.

"ORDER III. ALGÆ.

"*Vegetables*, for the most part aquatics, destitute of roots, or furnished only with a fibrous or scutate base for the purpose of attachment merely; having, for fructification, *seeds* or *sporules*. . . . . .

"Many species of this singular, and, generally speaking, beautiful order of plants, frequently float in the water without any point of attachment to extraneous substances. Their colour is various, often green, brown, red, &c."*

And, again, from the pen of an amiable naturalist, who has dedicated much of his attention to this humble but interesting order of the "Algæ," we have the following in his recent publication:—

"*Algæ* form part of that great Class to which Linnæus has given the name of Cryptogamia, because they are flowerless; but, like ferns and mosses, and other plants of the same great class, they possess what answers the purpose of flowers. . . . . The fronds of Algæ are not only variable in form but also in substance. Some are like masses of jelly; others are very gelatinous; others are like silk threads; others are cartilaginous; some as tough as leather; and others as firm as wood. . . . . . The prevailing colours which they exhibit are green, olive, and red in all their variety of shades. Those of a green colour generally grow in shallow water, the olive in deeper, and the red in deeper still, although in these respects there are several exceptions. . . . . .

"Algæ, or sea-weeds, have a wide geographical range, for I suppose wherever there is sea, sea-weeds of some kind are found. To a considerable extent, they seem to obey the same laws as land plants. Every zone presents a peculiar system of vegetation."†

"ORDER VII. FILICES.

"*Fructification* only of one kind on the same individual. *Capsules* spiked or raccined, or mostly collected into *clusters* of various

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* Flora Scotica, Part ii. p. 74.

† Popular History of British Algæ, by the Rev. Dr. Landsborough, 1849, pp. 9—35.

shapes (sori) upon the back of the *leaf* or *frond*, naked or covered with an *involucrum*, often surrounded by an elastic *ring*, opening irregularly, or without a *ring*, and opening with a regular *fissure*. *Seeds* or *sporules* minute. . . . . In the tropics the *caudex* forms a *trunk* resembling that of the palms."*

Of the stations of the various species enumerated, eight are particularised as being in "marshes and bogs;" "woody and wet rocky places;" "rocks by the sea side;" "wet rocks and along the shores of Loch Lomond (the *osmunda regalis*, the largest and handsomest of the British ferns);" and "meadows and moist places." The remainder seem to prefer shady woods and fissures of rocks.†

MM. De Candolle and Sprengel (in the Elements of the Philosophy of Plants), say—

"The remains of the former vegetable world belong almost entirely to the lower families; they consist for the most part of Grasses, Reeds, Palms, and Ferns, *the latter being almost always destitute of fruit.*‡

According to Professor Henslow—

"In the oolitic series fossil plants become more abundant, and some beds are remarkably characterized by the prevalence," amongst others, "of many ferns very distinct from those in the former formations."§

"A Fern," says Mr. Francis, "is a flowerless plant, which has a fibrous root, vascular stem, veined leaves, reticulated cuticle furnished with stomata, and bears spores as fruit in capsular receptacles. The Ferns and their allies form the first order of the Linnæan class Cryptogamia, and their structure shows such an intermediate character between the Vasculares and Cellulares, that all systems of classification have assigned them this station among vegetables. They are without flowers, have but imperfectly formed vessels, and no deposition of real woody fibre, therefore cannot with propriety be arranged with Phanogamous plants, while their semi-vascular texture, and their fully developed leaves shew their organization to be greatly above that of any other order of cryptogamic plants.

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* Flora Scotica, Part ii. p. 152.

† Ibid, pp. 152—158.

‡ Ibid, p. 276.

§ Botany, in Cab. Cyc. p, 312.

"Although the True Ferns have a direct analogy with the Palmæ and Cycadeæ, the connexion between them and other orders is more apparent in the Pteroides or Fern Allies, particularly the Equiseta and Lycopodia. . . . . Thus the tribes under consideration, which are divided according to the modern system into FILICIALES, LYCOPODALES, and EQUISATALES, the first the True Ferns, the other the Pteroides or Fern Allies, altogether form valuable, because well-connecting links in the great chain of nature.

"Ferns abound chiefly in the more woody and moist counties. Our larger species luxuriate on the banks of ditches. . . . .

"Moisture and shade are equally necessary to all the Fern tribe; they grow, therefore, for the most part in northern aspects, and on damp porous stones."*

"The reproduction of ferns," continues the same author, "is a subject involved in much obscurity. Hedwig, Bernhardi, and others have proposed theories to explain this intricate matter, but without success. . . . . At present nothing whatever has been discovered of the origin of the germinating principle in any of the cryptogamic orders; nor the laws which regulate the formation and development of their spores.

"As regards our present tribe, so keen has been the search, that every part of the plant has been subjected to the minutest investigation; not only the thecæ, their ring, and their cover, but the spiral vessel of the rachis, the stomata upon their cuticle, and the glands which are sometimes found attending upon them."†

"ORDER IV. CHARACEÆ.

"*Fructification* of two kinds. Nucleus 4, bracketed, standing solitary, &c. *Seeds*, or *sporules*, very minute, whitish, spherical, &c.

"*Vegetation.* Aquatic plants never rising above the surface of the water, fixed into the mud by slender fibrous radicles issuing from a swollen portion of the stem," &c. "A minute fossil body frequently found in chalk, which is spirally twisted, and which was formerly considered to belong to the animal kingdom, is, I believe, now generally allowed to be the *kukule* of *chara*. Various species have been discovered, and they are called by the French, gyrogomites."‡

"As the *chara*," says Mr. Lyell, "is an aquatic plant, which

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* Francis on Ferns and their Allies, 1837, Introduction, pp. 1, 2.

† British Ferns, p. 5.

‡ Flora Scotica, Part ii. pp. 108, 109.

occurs frequently fossil in formations of different eras, and is often of much importance to geologists in characterising entire groups of strata, we shall describe the manner in which the recent species have been found in a petrified state. . . . . In some species, as in *chara hispida*, the plant, when living, contains so much carbonate of lime in its vegetable organization, independently of calcareous incrustation, that it effervesces strongly with acids when dried," &c.*

"ORDER VIII. LYCOPODIACEÆ.

"*Fructification* bracteated, auxilliary, or spiked. *Capsules* frequently of two kinds on the same plant, 1-3 celled, 2-3 valved, containing many minute *granules*; or a few larger *corpuscles*. Roots fibrous. *Stems* herbaceous or woody, simple or branched, often creeping. Of five *habitats*, two are 'wet heathy places, and by the sides of lakes,' and 'boggy places by the sides of rivulets on the highland mountains,' the others are on rough, stony, heathy mountains."†

Mr. Lyell explains *Lycopodineæ* as—

"Plants of an inferior degree of organization to coniferæ, some of which they very much resemble in foliage, but all recent species are infinitely smaller. Many of the fossil species are as gigantic as recent coniferæ. Their mode of reproduction is analogous to that of ferns. In England they are called club-mosses."—*Glossary*, p. 72.

"ORDER IX. MARSILEACEÆ.

"*Fructification* radical. *Involucrum* sub-spherical, not opening, coriaceous, or membranaceous. One or many celled. Aquatics. *Hab.* bottoms of the highland lakes, and damp places that are overflowed during winter, but not common, &c."

"ORDER X. EQUISETACEÆ.

"*Fructification* terminal, spicate, consisting of peltate polygonous scales, on the under side of which are from 4-7 involucres, which open longitudinally, and contain numerous naked (?) seeds, unfolded by four filaments bearing anthers (?) at their extremities.

"*Vegetation: stems* rigid, leafless, jointed, striated, the articulations sheathed at the base, the branches whorled.

"*Habitat*, 'wet marshes;' 'shady marshes,' and 'the brinks of

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* Principles of Geology, vol. ii. pp. 280, 281.

† Flora Scotica, p. 159.

stagnant waters;' 'moist shady places;' 'lakes and ditches,' 'ditches and wet soils.'"

"MONOCOTYLEDONS.

"ORDER XVIII. FLUVIALES.

"*(Part of Naiades. Juss.)*

"Flowers unisexual or bisexual. Ovary 1 or more superior. *Seed* solitary, pendulous, or suspended. *Embryo* without *albumen*, having a contrary direction to the *seeds*, with a lateral *cleft* for the emission of the *plumule*. Floating *herbs* with very vascular leaves and stems. *Flowers* inconspicuous."*

CYCADEÆ.

By referring to Messrs. Lindley and Hutton's Fossil Flora, it will be perceived, that the fossils classed under this *Order* are known only by their leaves, and are found in the lias, the oolite, and the grey chalk formations.

"The *Cycadeæ* form the passage from the *palms* to the *ferns*."—*Sprengel.*

"The *Cycadeæ* have great proximity to the ferns."—*Lindley.*

"The associated fossil plants (in the coal formation), although imperfectly known, tend to the same conclusion (an elevated temperature), the *Cycadeæ* constituting the most numerous family." —*Lyell*, vol. i. p. 116.

In addition to these descriptive notices we consider it opportune to subjoin the following extracts of a more general character. They will likewise prove the extreme warmth which everywhere prevailed during the period we are now treating of:—

"We learn," says Mr. Lyell, "from the labours of M. Ad. Brongniart, that there existed at that epoch during the formation of the Coal measures, Equiseta upwards of ten feet high, and from five to six inches in diameter; tree ferns of from forty to fifty feet in height, and arborescent Lycopodiaceæ of from sixty to seventy feet high. Of the above classes of vegetables, the species are all small

* Flora Scotica, Part ii. p. 192. The *Naiades* are placed by MM. De Candolle and Sprengel, in their Elements of the Philosophy of Plants, amongst the Acotyledons. See p. 139.

at present in cold climates; while in tropical regions there occur, together with small species, many of a much greater size, but their development at present, even in the hottest parts of the globe, is inferior to that indicated by the petrified forms of the coal measures. An elevated and uniform temperature, and great humidity in the air, are the causes most favourable for the numerical predominance and the great size of these plants within the torrid zone at present." In a note to this paragraph it is added, "Martins informs us that on seeing the tessellated surface of the stems of the arborescent ferns in Brazil, he was reminded of their prototypes in the impressions which he had seen in the coal mines of Germany."*

Mr. Miller, in his usual graphic style, expresses himself—as we have already quoted with reference to animal exuviæ—with respect to this uniformity of ancient flora, in the following remarkable words:—

"In the more ancient geological periods, ere the seasons began, the case is essentially different. The contemporary formations, when widely separated, are often very unlike in mineralogical character, but in their fossil contents they are almost always identical. In these earlier ages, the atmospheric temperature seems to have depended more on the internal heat of the earth, only partially cooled down from its original state, than on the earth's configuration or the influence of the sun. Hence a widely spread equality of climate—a green-house equalization of heat, if I may so speak; and hence, too, it would seem, a widely spread flora. The green-houses of Scotland and Sweden produce the same plants with the green-houses of Spain and Italy; and when the world was one vast green-house, heated from below, the same families of plants seem to have ranged over spaces immensely more extended than those geographical circles in which, in the present time, the same plants are found indigenous.

"The fossil remains of the coal measures are the same to the westward of the Alleghany Mountains as in New Holland, India, Southern Africa, the neighbourhood of Newcastle, and the vicinity of Edinburgh. And I entertain little doubt that, on a similar principle, the still more ancient organisms of the old red sandstone will be found to bear the same character all over the world."†

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* Principles of Geology, vol. i. pp. 116, 117.

† Old Red Sandstone Formations, pp. 197, 198.

Although we have already and so recently put on record Sir Henry de la Beche's opinion, yet, as it is of interest, we again briefly recur to it:—

"Respecting the general character of the vegetation we find entombed in the carboniferous rocks of the Northern hemisphere, M. Ad. Brongniart observes, that it is remarkable, 1st. for the considerable proportion of the vascular cryptogamic plants, such as the *Equisetaceæ*, *Filices*, *Marsileaceæ*, and *Lycopodiaceæ* ; 2nd. for the great development of the vegetables of this class, proving thereby that circumstances were particularly favourable to their production during the period under consideration. . . . . .

"This view leads us to another consideration. There certainly was a similar vegetation about the same period (for whether the American coal measures may be, like those of Ireland, somewhat older, does not alter the question) over parts of Europe and North America; we may, therefore, infer a similar climate over a large portion of the Northern hemisphere, such as we have not at present, for it was at least tropical, and very probable ultra-tropical."*

In confirmation of Mr. Lyell's opinion Mrs. Somerville says—

"Now it appears that most of the European, North Asiatic, and North American Continents and Islands, were raised from the deep after the coal measures were formed, in which the fossil tropical plants are found; and a variety of geological facts indicate the existence of an ancient and extensive archipelago throughout the greater part of the Northern hemisphere."†

Professor Henslow says—

"Many local circumstances produce remarkable modifications in the relative proportions between the species of different classes and orders in regions under the same parallels of latitude. Thus, for instance, *ceteris paribus*, the cryptogamic tribes flourish most in moist regions. The places best adapted to the growth of ferns are the islands in tropical climates, in some of which, as in St. Helena, one half of the flora is composed of them. It is remarkable that in

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* Manual of Geology, 2nd edition, pp. 429—431.

† Connexion of the Sciences, pp. 86, 87.

this respect, and as regards the existence of arborescent species in this order, the ancient flora of our coal fields appears to approximate very closely to that of islands situate in the midst of an extended ocean and in low latitudes. The same causes which appear favourable to the increase of cryptogamic species, seem also to produce a diminution in the proportions which dicotyledons bear to monocotyledons."*

And we shall conclude this part of our evidence with a few sentences from the work of those indefatigable fossil botanists, Messrs. Lindley and Hutton :—

"In the *coal formation*, which may be considered the earliest in which the remains of land plants have been discovered, the *flora* of England consists of *Ferns* in amazing abundance; of large *Coniferous* trees of species resembling *Lycopodiaceæ*, but of most gigantic dimensions; of vast quantities of a tribe analogous to *Cacteæ* or *Euphorbaciaceæ*, but perhaps not identical with them; of some *palms* and other monocotyledons, and, finally, of numerous plants the exact nature of which is as yet extremely doubtful. About two to three hundred species have been detected in this formation, of which two-thirds are *Ferns*. . . . . This vegetation, thus inconceivably rich and luxuriant, grew amidst an atmosphere that would have been fatal to the animal kingdom, ... in consequence then of the greater abundance of carbonic acid gas than now. . . . To this there are no botanical objections: whether such an atmospheric condition was unfit for animals is not our province to enquire. . . . . .

"It may be observed that no trace of any *glumaceous* plant has been met with, amongst the fossil flora, even in the latest tertiary period; although we know that *grasses* now form a portion, and usually a very considerable one, of every recent *flora* of the world, from New South Shetland to Melville Island inclusive; it may, indeed, be conjectured, that before the creation of herbiverous animals, grasses and sedges were not required, and, therefore, are not to be expected in any strata below the Forest marble and Stonesfield slates, but it is difficult to conceive how the animals of the upper *tertiary* beds could have been fed if grasses had not then been present."†

* Botany, in Cab. Cyc. p. 309.

† MM. Lindley and Hutton's Fossil Flora, Introduction, vol. i. pp. x. xi. xxiii.

The general impression left upon the mind, after perusing these copious extracts, is, that the plants which constituted the carboniferous portion of the coal measures delighted in warmth, carbonic acid gas, and moisture, and having enjoyed these three requisites in an abundant degree, they increased to gigantic proportions when compared with recent equivalents: while the more particular inferences to be drawn from the same quotations are, that with respect to the *Algæ*, *Marsilaceæ*, *Equisetaceæ*, *Naiades*, and *Characeæ*, undoubted evidence has been adduced, to prove, *that water being their natural element, in it they grow and propagate.* But it is not equally conclusive with respect to the remaining orders, the *Filices*, *Lycopodineaceæ*, and perhaps the *Cycadeæ*; for it has only been shown that certain of their species prefer moisture and the proximity of water as their favourite localities.

However, when in unison with Professor Henslow, we reflect, that "fossils bear an analogy to some recent genera, which they closely resemble, but to which they cannot be accurately referred; the resemblance being indicated by classifying them provisionally with a genus; for example, 'Lycopodites,' a genus of fossil plants allied to 'Lycopodium,' but too imperfectly known to have its characters fully pointed out;"* and at the same time discover, by a glance at the several *habitats* of the *Filices*, such a diversity in their *stations*, and consequently in their nature, as to induce the *Asplenium alternifolium* to flaunt in the sunny crevices of Alpine rocks, while the graceful *Osmunda regalis* dips in the waters of the lakes which are formed by these mountains, it will not surprise any one if we should entertain but little anxiety as to the eventual decision of the question; for it may ultimately be discovered, that the fossil *Ferns*, *Lycopodineaceæ*, and *Cycadeæ*, were of a nature capable alike of growing and propagating under water; and as we shall hereafter have occasion to show, *that unless they grew under water they did not grow at all*, while by their remains found in the ancient strata their existence cannot for a moment be doubted, the only proper inference which can be drawn is, *that they grew submersed in*

* Botany, in Cab. Cyc. p. 311.

the ocean which circumbounded the Earth during its period of non-rotation.

This opinion is greatly strengthened by Dr. M'Culloch's reasoning on the origin and nature of the coal formations; for the whole of his arguments relating to this interesting geological question go to prove, as conclusively as language is capable of effecting it, that the independent coal formations have arisen from the remains of *aquatic cryptogamous plants,* with a few exceptions, which he supposes *not to have been of submerged habits.* But as the coal immediately overlies, and is in turn overlain by *marine* formations, to reconcile this with his preconceived hypothesis, of Coal proceeding from Peat, as at present formed, he is under the necessity of assuming that the submarine strata of mountain limestone *was raised above* the level of the ocean in order to enable these aquatic and lacustrine peat-forming plants to generate sufficient of that material; and this being done, they are supposed to have been *depressed* by another revolution, to permit the submarine deposits, the magnesian limestone, and the new red sandstone to be formed above them again; when, by a succeeding revolution, they were raised to the position which they have occupied since the duration of the historical period; while, to account for the occasional intermixture of marine formations *contemporaneously* with the coal formations themselves, he is obliged to suppose, that besides extensive lakes and marshes, there also existed innumerable estuaries in the ancient world.

Now, as we shall, in the sequel, make it abundantly evident, *that there has been only one general elevation of the strata,* which will likewise satisfactorily explain the *apparent* depression of the coal fields and their overlying rocks, we consider Dr. M'Culloch's evidence, although indirect and unconcious, the most conclusive which can be produced *in favour of the submarine nature of the plants whose remains have formed the Coal of the great or independent formations.*

In proof of what has just been said, relative to Dr. M'Culloch's opinion, the reader will please to peruse the following succinct quotations from the work to which we have alluded:—

"The progress of fossil botany," says he, when treating of these formations, "is as yet so imperfect, and those remains are often

so broken and obscured, that not much has been done towards their effectual description and arrangement. For that information which does not fall within the plan of this work, the reader must be referred to Sternberg, Schlotheim, Brongniart, and others, or to the abstract of Conybeare and Phillips. It is sufficient to remark that plants of aquatic habits seem to prevail among them; the predominant remains being those of gigantic vegetables resembling *equisetums* accompanied by others analogous to *ferns* and *lycopodiums*, and, as it is thought, to *palms*; with some which appear to possess no exact living analogies. . . . . . The genera in all seem to be very limited, as far as they can be determined from such imperfect specimens; but it is imagined that the species exceed three hundred, or approach to four. . . . . .

"Maritime peat appears to have been almost forgotten by the writers on this subject; but it is formed under the sea by the *Zostera Marine* abundantly, while it is produced in another manner by the plants of salt marshes. . . . . .

"It is essential to remark that the old red sandstone, the mountain limestone, and the coal series are all disturbed; being elevated, undulated, and fractured in various ways, as I have often already been compelled to notice. And it must similarly be recollected that a new order commences with the magnesian limestone and the red marl; or that they are placed on the coal series and the inferior strata in an unconformable position, while the lower parts also present that conglomerate structure which, everywhere throughout nature, accompanies a new order in rocks. . . . . .

"Such are the organic appearances connected with coal; all of them bespeaking a terrestrial, not a sub-marine, origin, for the general series in which it is found. Their aquatic nature equally indicates the growth of these vegetables in low, moist forests, in marshes, or on the borders of lakes or rivers. In the repetition of different strata, we see the successive deposition of earthy matters of different natures, afterwards consolidated into sandstone or shale, or else remaining unconsolidated; while the repetition of carbonaceous beds, no less than the deposition of vegetable strata alternating with the laminæ of the shales, shows that successive generations of plants had followed successive depositions of earth. To the same circumstances of repose, the solution of soluble earths, pressure, and, it is probable, to heat, we must attribute equally the consolidation of the rocks and the conversion of the vegetable deposits into coal.

"Although the vegetable nature of these remains thus indicates the *terrestrial* origin of the series, the subjacent limestone contains *marine* remains. These strata, then, as I remarked under former general views, have been formed under the sea, of which the bottom must have been elevated prior to the deposition of the coal beds. That the vegetables could *not* have been transported from their places of growth to that position is no less proved by the integrity of the most delicate specimens than by the erect trunks of trees above-mentioned. Yet, though assuredly formed on the supra-marine land, it may still seem difficult to account for the great thickness of many deposits, and for the frequent alternations of rocks and of vegetable matter. The existence of deep lakes, at some period and under various modifications, is necessary to explain the phenomena; though it may be difficult to conceive the exact details of the changes, and the condition of the surface necessary for their production. . . . . . It is not difficult to explain the presence of *marine* bodies, or even of complete *marine* strata, if such there really are in any coal series. It is merely to suppose an estuary instead of a lake; and it has already been shown that the mode of deposition and the alternation of the substances are at present similar in both.

"From the *marine* origin of the strata above the coal series, it has formerly been shown that those parts of the surface which were once above the water, and which received the deposits of land vegetables, have been subsequently immersed beneath an ocean during the period of unknown, but great duration, requisite for the accumulation of such enormous masses. The last change restored to the surface of the Earth, and often to great elevations, those strata which had once before occupied it, accompanied by all those which are found above it, and by many of those which lay below. Such changes could not have taken place without violence and derangement, and to them we must attribute those fractures, dislocations, and flexures of the coal strata, no less than those of the other rocks which have undergone analogous changes."*

The whole of Dr. M'Culloch's reasoning proceeds on the admitted supposition that the vegetation of the coal measures, throughout, was composed of *Cryptogamous plants of aquatic habits*. On this point he never manifests the slightest doubt; indeed so much the reverse, *that the difficulties of his position*

* Geology, by Dr. M'Culloch, vol. ii. pp. 310—313, 341.

arise entirely from the soundness of his belief on those two points, inasmuch as he found it a difficult task, under his own preconceived ideas of the condition of the earth's surface, during the period of their growth and propagation, to account for their presence! It was not considered necessary by him, and consequently by those with whom on this point he concurrred, to prove that the plants were *cryptogamous and aquatic*, for on that they were agreed; but it appeared comparatively so to account for their presence under supposed circumstances, and surrounded by other demonstrations which do not entirely conform with our present ideas of aquatic plants. This obliged him to imagine several successive elevations and depressions of the earth's surface—even unequal depressions in the same locality—the credibility of which stood merely on his own supposition, and which, without further proof, might have been balanced by any other gratuitous assumption. But his other position of the *cryptogamous character and aquatic habits of the plants* having been by collateral evidences satisfactorily made good, it follows that they should have been considered by him, not only to have been *aquatic, but capable of growing and of propagating when submerged.* Had Dr. M'Culloch admitted this additional feature, and asserted, as we do, that there was only one general elevation and depression of the rocky formations of the earth, that which took place when it was made first to revolve, all the difficulties attending his argument, so far as it went, would have immediately disappeared.

But it must not be supposed that because we have adopted those views we have overcome all the difficulties which beset our path when endeavouring to explain our hypothesis, or to make it acceptable to others. Very far from it. We are scarcely across the threshold; and are, besides, exposed to the imminent danger of proving too much on the one hand, or too little on the other. Indeed, peculiarities of those two kinds obtrude themselves as obstacles to our advance beyond our present position. We are in danger of being considered to have "proved too much," unless we can give some satisfactory reason for the absence of several orders of *cryptogamic* plants which, on the supposition that all of this class were excluded

from the creative command given on the third day of the Mosaic week, should, consequently, have been discovered amongst the fossil remains of the *ancient flora;* but which are not generally mentioned by geological botanists as forming part of their collections; and, on the other hand, of having "proved too little" unless we can explain the state of the primeval water so satisfactorily as to show that plants usually requiring *fresh water* could have lived, grown, and propagated at the bottom of the original circumfluent ocean. We shall take these difficulties in the order in which they stand, and first endeavour to account for the absence of *Fungi, Lichens, Hepaticeæ, and Musci,* which have not, we understand, been discovered fossil or perfectly identified in any of the geological formations below the chalk;* while it must be remembered, that the point being wholly negative, the proofs, to the limited amount obtainable, will partake of the same character.

"ACOTYLEDONS.

"ORDER I. FUNGI, *Linn. (Fungi, and part of Algæ, Juss. Fungi, and part of Hypoxylia, Decand.)*

"Plants growing upon the ground, or parasitic on other vegetable substances, rarely (never?) aquatics, and scarcely ever green, filamentous, gelatinous, spongy, corky, coriaceous, fleshy, or membranaceous. . . . . . The *seeds* or *sporules* are either internal, as in *Sphæria*, Bovista, or external, as in Agaricus, &c. After being once dried they do not revive by the application of moisture, like the greater number of plants in this class; and, generally speaking, they are of very short duration, soon decaying, and frequently becoming putrid in decay."†

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* Since writing this we have seen the following corroborative passage in MM. Lindley and Hutton's Fossil Flora, vol i. p. xviii., when they were endeavouring to combat the opinion of M. Ad. Brongniart and his reviewers, "that nothing but *cryptogamous* and *monocotyledonous* plants existed in the Coal measures," they ask, "what trace is there of the simplest forms of flowerless vegetation in the Coal measures, such as *Fungi, Lichens, Hepaticeæ,* or *Mosses?* to say nothing of *Confervæ.* Many of these would have communicated their casts as distinctly to the matter which enclosed them as *Ferns* or *Lycopodiaceæ,* had they existed; but no traces of them are found; while we have," say they, "on the contrary, in their room, the most perfectly organized plants of the Flowerless or Cryptogamic class, namely, *Ferns, Lycopodiaceæ,* and supposed *Equisetaceæ.*"

† Flora Scotica, Part II. pp. 3, 4.

"ACOTYLEDONS.

"Order II. Lichens, *Ach.* *(Lichens, and part of Hypoxylia, Decand. Part of Algæ, Juss. Genus Lichen, and some Byssi, Linn).*

"*Universal recept. (thallus, crust, or frond),* polymorphous, without roots, perennial, abounding in excessively minute bodies for the purposes of propagation, either embedded in the substance or scattered upon its surface, or included in peculiar organs, which have been considered the *fruit* (partial receptacles, or *apothecia*; by some called *shields*, or *scutella* and *tubercules).*"*

"With regard to the most simple forms of vegetation," says the writer on botany, from whom we have so often quoted, "such as *Fungi, Lichens, and Sea-weeds,* the subject is involved in so much greater mystery (than the higher bodies of cryptogamic plants) that there are to this day botanists of no mean reputation who believe such plants to be produced by means almost analogous to equivocal generation."†

"ACOTYLEDONS.

"Order VI. Musci.

"Fructification of two kinds. *Capsules,* in an early stage, covered with a calyptra, tipped with a style, which bursts transversely and regularly, and rises up mostly with a pedunculated and operculated capsule, ... and spherical pedicellated reticulated *bodies,* concealed for the most part in peculiarly shaped leaves, which have been considered *anthers.* *Plants* of small size, of a more or less compactly cellular structure, readily reviving by the application of moisture after being dry.

"The following are some of the *stations* of this extensive and widely extended order of plants. To avoid being diffuse the *genera* only have been particularised:—

Splagnum—Bogs, marshes, and growing in water in boggy places.

Gymnostomum—Wet and moist rocks, ditches, and banks near the sea.

Weissia—Turf bogs, and oozy shady rocks, clayey places, and moist banks.

Dicranum—Moist banks, marshes, very wet situations, and sides of streams and rivers.

Trichostomum—In rivulets. Moist banks.

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* Flora Scotica, Part II. p. 35. † Library of Useful Knowledge, p. 118.

FONTINALIS—Rivers and lakes. Alpine and sub-alpine rivulets.
HOOKERIA—Moist banks in woods, &c.
HYPNUM—Banks of rivers and lakes, and spots occasionally overflowed with water. Bogs and marshy places."*

"ACOTYLEDONS.

ORDER V. HEPATICEÆ. *Juss. Decand. (part of Algæ, Linn. Calyptratæ Deoperculatæ, Mohr.)*

"*Fructification*, generally of two kinds. *Capsules* in an early stage covered with a *calyptra*, tipped with a style (?), and then often surrounded by a *perianth* or *calyx*, at length bursting the calyptra irregularly. *Minute plants*, frequently frondose, sometimes (as in Jungermannia) folliferous; *substance* loosely cellular in general, easily reviving after being dried, by moisture. Sometimes the areclæ of the cells have an evident pore, as in *Marchantia and Targionia.*

"The following are some of the *stations* of the *genera* belonging to this order:—

RICCIA—Turfy marshes among the Scottish mountains.
JUNGERMANNIA—Moist rocky places, marshy grounds, bogs, and boggy places, and growing in water.
TARGIONIA—Moist banks.
MARCHANTIA—Shady moist rocks, wet rocks and banks, and moist shady banks by the sides of rivulets."†

These evidences are all that recent botany affords us. They amount to very little as far as our argument is concerned, as they merely prove the imperfect, rudimentary character of the missing plants, and their capability of having existed in moist, wet places, or perhaps submerged in some of their conditions; but they afford a very slender clue indeed when we seek to unravel the mystery of their *non-appearance* (we would not say *absence*) amongst their associated Orders in the fossil remains of the primitive world. We must, therefore, turn with increased earnestness to collate from the writers on *fossil* botany whatever they may have put on record in this matter. The Orders of the inferior plants which we wish to account for, are, 1st. *Fungi*; 2nd. *Lichens*; 3rd. *Hepaticeæ;*

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* Flora Scotica, Part II. pp. 120—152. † Ibid, Part II. pp. 109—120.

and 4th. *Musci.* Now, we find that indefatigable investigator Dr. M'Culloch, expressing himself thus: "I have proved in the Geological Transactions what has been denied, namely, that minute vegetables are preserved in chalcedony. These are the so-called Moss Agates. . . . . . In my collection three or four *mosses,* one possibly a *Jungermannia,* and a *Lichen,* which admit of no dispute."* As *Jungermannia* is an *Hepaticeæ,* and he alludes besides to a *Lichen,* and to some *Mosses,* we have thus three of the *Orders* in question accounted for in one short, but pithy sentence, in which the writer points to proof positive, asserting that in his collection those fossil vegetables exist, may be examined and believed in, for they "admit of no dispute."†

Mr. Lyell—when engaged in that part of his geological treatise which required him to explain the origin of peat—states, that—

"The generation of peat when not completely under water is confined to moist situations, where the temperature is low, and where vegetables may decompose without putrefying. It may consist of any of the numerous plants which are capable of growing in such *stations;* but a species of moss *(sphægnum palustre),* constitutes a considerable part of the peat found in marshes of the north of Europe; this plant having the property of throwing up new shoots in its upper part, while its lower extremities are decaying. . . . . . Reeds, rushes, and other aquatic plants may usually be traced in peat; their organization is often so entire that there is no difficulty in discriminating the distinct species."

At another place he says—

"From the researches of Dr. M'Culloch it appears that peat is intermediate between simple vegetable matter and lignite: the conversion of peat into lignite being gradual, and being brought about through the lapse of time, and the prolonged action of water."‡

Our esteemed friend, the Rev. Dr. Landsborough, thus

* Geology, by Dr. M'Culloch, vol. i. p. 414.

† In the *Fossil Flora, Musci* and *Characeæ* will be found, Gen. 84, 85, but both above the chalk.

‡ Principles of Geology, vol. ii. p. 216, 217.

appropriately expresses himself, when bearing testimony to an analogous fact:—

"He, who by a word clothed the rocks and channel of the sea with so much riches and beauty, and who said, respecting the miraculous supply of food in the wilderness, "Gather up the fragments that remain, that nothing be lost," allows not even the fragments of sea-weed to be lost. Man has learned the wisdom of gathering up those that are within his reach, but a kind Providence allows not to be lost the immense masses that are buried at the bottom of the sea.

"He who in primeval ages stored up the remains of ancient forests, converting them into coal for the succeeding generations of men, at the same time stored up the wreck of marine matter in the form of stone, of which the palace and the cottage might be built. We cannot examine a limestone quarry without seeing that it must have been consolidated in the depths of the sea.

"Though sea-weeds, being more perishable than the shelly coats of animals, are less frequently observed in marble or limestone, yet they are occasionally seen. In a quarry near to Ardrossan, I saw numerous dark impressions of a large sea-weed, resembling *Halidrys*.

"Nay, we have practical proof (by Marshall's Patent *Intonaca* Compost), that the *dejecta membra* of sea-weeds buried in the mud, are well fitted to contribute to its consolidation."*

But, perhaps, no evidence whatever can be more conclusive on this point than that which is afforded by the experiments of Professor Lindley, an account of which we prefer taking from Dr. Buckland's Bridgewater Treatise, as we acquire thereby their conjoint testimony, which, on a subject of this description, must be considered paramount to any other.

"The following are the results of Professor Lindley's experiments on the *durability* of plants immersed in water; 177 specimens, including representatives of all those which are either constantly present in the coal measures, or as invariably absent, having been immersed in a tank of water for two years, he found

1. That the leaves and bark of most *dicotyledonous* plants are wholly decomposed in that period, and that of those which do resist it, the greater part are *coniferæ* and *cycadeæ*.

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* Pop. Hist. of British Algæ, pp. 65—68.

2. That *monocotyledons* are more capable of resisting the action of water, particularly palms and *scitamineous* plants; but that *grasses* and *sedges* perish.

3. That *fungi*, *mosses*, and all the lowest forms of vegetation disappear.

4. That ferns have a great power of resisting water if gathered in a green state, not one of those submitted to the experiment having disappeared; but that their fructification perished."

On these Dr. Buckland remarks in a note—

"It may be further noticed, that as both trunks and leaves of *angiospermous dicotyledonous* plants have been preserved abundantly in the tertiary formations, there appears to be no reason why, if plants of this tribe had existed during the secondary and transition periods, they should not also occasionally have escaped destruction in the sedimentary deposits of these earlier epochs."*

The result of this evidence respecting those minor classes of the *cryptogamous* plants whose infrequency amongst the *fossil* specimens found in the strata has occasioned this enquiry, seems to be, that while, on the one hand, the experiments of Professor Lindley afford sufficient reason for removing any anxiety which might arise from their prevailing absence, where fossil remains of other orders are so abundant; the testimony, on the other hand, of Dr. M'Culloch and concurring writers shows, that they are occasionally met with in a fossilized state; thus making it manifest that the experience of fossil botanists corresponds precisely with what might have been expected from the perishable nature of those minute cryptogamous plants, and the attendant circumstances during the period of their existence: a corroboration which ought entirely to remove any lurking doubt that may have remained.

Generally, it may be asserted with regard to them, that their rudimentary character—forming, as by concurring testimony they seem to have done, the primary elements in coal through its gradations of peat, lignite, &c.—would necessarily expose them to be wholly obliterated by transmutation during a lapse of ages into carbonaceous material; it being physically impos-

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* Prof. Buckland's Bridg. Treat. vol. i. pp. 410, 481.

sible to possess both the coal fully formed and the separate elementary materials of which it is composed; while, in other cases where circumstances were not conducive to their transmutation into coal, the effects produced by immersion, as shown by Professor Lindley, may have taken place, and the rudimentary, perishable descriptions of plants have disappeared, although the higher and more robust grades of cryptogames resisted the action and became fossilized.

It has not unfrequently occurred to us that, reposing with confidence on the truthfulness of the record of Scripture, and on the soundness of the views we have adopted by its assistance, we might have left this question to adjust itself in the course of time, and when discussion had more thoroughly brought to light the direction which the line of separation takes between *flowering* and *flowerless* plants in the Vegetable Kingdom. Perhaps we would not have mooted this question at all, had it not been from a feeling, something between a desire to leave no weak point behind us unexplored, and that of pushing our principle as far as it will go; and with it to test the soundness of the conclusions of those who have dedicated themselves to the fields of labour through which we now wend our way. Should it be considered rather too bold an attempt, in the present state of the question, to endeavour to reconcile and thoroughly to make at one so general an assumption as the *non-rotation of the earth while darkness reigned over it*, with the minute and intimate nature, habits, and perfect adaptation of the lowest *orders* in the most inferior *class* of plants; and that, too, notwithstanding the divergency of opinion prevailing amongst botanists as to their systematic classification, it must be attributed only to the perfect confidence in the general soundness of our views, and in the firmness of the foundation on which they all repose; while we think it does not add a little to their corroboration to find that, without the slightest diminution of our general confidence, it is precisely at the same point where botanists have not sufficiently made up their minds as to the classification of the objects of their research, that we begin to falter and be at a loss how to proceed. We firmly believe that the faithful application of the comprehensive rule laid down in

Scripture will clear up both of our paths, and show us *that although during the protracted period of non-rotation and darkness there existed at the bottom of the atmosphereless ocean innumerable families of plants, not one of them was furnished with any traces of either flowering or seeding processes*, in the true and full acceptation of these terms. That, in fine, although for ages previously there had been myriads of what are now called *imperfect* flowerless plants secreting carbonaceous material for future purposes, there was not, until the period represented by the third day of the Mosaic week, a single perfect or flowering, seeding plant within the whole range of the solar system!

The difficulty of another description, to which we alluded, namely, that of "proving too little," still remains to be disposed of. For, after it has been made out that the whole of the objects comprising the *cryptogamous* class of plants have been discovered in a fossil state, and that they could have existed and propagated in a submerged condition, the doubt still remains whether they could have done so *in the waters of the primeval ocean,* considering them to have been impregnated with saline materials, as manifested, amongst other vestiges, by the extensive deposits of salt found in the new red sandstone, and other associated formations. Before, however, this explanation can be satisfactorily given, or conclusively understood and relied on, we shall require to have our labours considerably more advanced, and our cosmographical views further unfolded. When that is the case we have no doubt but we shall make it abundantly evident that although in reality the waters of the primeval ocean did contain all the elements which go to the formation of salt, yet other co-existent ingredients held these in a different state of combination, and caused the entire mass to be altogether distinct from the saline waters of our present seas. We shall then, also, be in a position satisfactorily to account for the deposition of culinary and other native salts in the new red sandstone and associated formations, and thus at one and the same time remove two obstacles to the complete establishing of the one great fact, *That during a long but indefinite period of its early geological history, the Earth did not rotate around its axis.*

SECTION III.

THE VEGETABLE ORGANISMS OF THE NON-ROTATORY PERIOD.

CHAPTER VII.

Another brief review of the progress made, and its application to the development of the general argument. Adaptation of the Plants of the non-rotatory period to the state of creation during that epoch. Fronds and folliacious appendages of Cryptogames described—contrasted with the respiratory expansions of Phanogames; and the design of the former being demonstrated, they are shown to be in harmony with the effects which the flowerless plants were intended to produce, namely, absorption from the surrounding water, retention of carbonic acid, and deposition, by their roots, to assist in forming the carboniferous strata. Short concluding observation: the continuity with which the subject has been traced to the present convergent point.

Having reached another convenient resting place, we may again look around us for a moment on commencing this chapter, to consider what has been done, and to see how far we have advanced in the general argument, which has been somewhat delayed by the investigation of those two minor points which threatened to oppose our progress, when we had acquired a sufficiently accurate knowledge of the distinguishing characteristics of the three classes into which all known plants are grouped by the natural system of botany; and had compared them, thus arranged, with the comprehensive description given in Scripture of the creation of vegetable substances,* in doing which we found, that this latter had reference merely to *seeding* and *fruit bearing* plants, *to the exclu-*

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* Genesis i. 11, 12.

sion of all others—a singular anomaly which constrained us to look elsewhere and to other manifestations of creative energy for the origin of the *flowerless, seedless, fruitless* plants. During our research we found, that writers on fossil botany had announced their having discovered amongst the stony tombs of earlier geological periods, the fossilized remains of plants, some of them in perfect preservation, resembling in almost every respect the *Cryptogames* or *Acotyledons*, whose origin we were in quest of: a remarkable coincidence in epoch, locality, and character of no small importance to our argument, and leaving little doubt on the mind, that the command given on the third day of the Mosaic week had exclusive reference to the two more perfect classes of flowering, seeding plants in correspondence with the altered condition of our planet after the formation of the light; whilst the *Cryptogames* had existed during the period of darkness or of non-rotation. This led to a new set of enquiries, namely, to prove the adaptation of this latter class to the primeval condition of the earth; but as direct evidence of this was not attainable, we endeavoured indirectly to make good that position, by showing that the two other classes, comprising the flowering plants, could not possibly have then existed; although these disabilities neither apply by assumption, nor yet by the direct experience of botanists, against the possibility of at least the greater proportion of the cryptogamous plants, or plants analogous to them, growing under the supposed circumstances of the earth previous to its rotation. While engaged in these enquiries we brought out, in the clearest manner possible, that the respiratory functions of plants, which reside in their leaves and other green parts, together with the decomposition of carbonic acid, and the fixation of carbon, depend on the direct light of the sun's rays acting upon these folliaceous appendages.* These facts being at direct variance with a state of matters which would apply to plants existing during the non-rotatory period, and while as yet there was no sun-light (the fundamental principles of this theory), it consequently becomes imperative on us, in continuation, to

* Theorems, Nos. 44, 118, and 120.

show the adaptation of *cryptogamous* plants, such as the discoveries of geologists have revealed to us, were the occupiers of the submerged surface of the earth—to the other attendant circumstances of the period alluded to; and, at the same time, to point out the probable uses to which they were applied, in the exercise of their functions, by the all-wise Creator, during the protracted ages which anteceded the formation of the light.

To effect this purpose we must first direct the attention to part of the *hundred and fifteenth* Theorem, relating to the *fronds* and *imperfect leaves* of the cryptogamous plants, and follow it with a more detailed description of these appendages, in order that their physiological structure and uses may be thoroughly understood.

"The higher tribes of cryptogamic plants," says Professor Henslow, "contained in the division '*Ductalosæ*' have green expansions, much resembling leaves in their general appearance, and, like them, possessing stomata; but differing from them very considerably in some respects, especially in bearing the fructification upon their surface. These have, therefore, received a distinct appellation, and are called 'fronds;' and that part of a frond which is analagous to the petiole is termed the 'stipes.' . . . . . In several tribes the fronds possess nerves, but in many cases they are composed entirely of cellular tissue. . . . . . The lower tribes of cryptogamic plants included in the division '*cellulares*,' are very often homogenous in their structure, and of different degrees of consistencies, from highly gelatinous to tough and leathery. When they consist of a plane membranaceous lamina, as in the *lichens*, this is termed a '*thallus*;' but when more or less branched, the name of frond is retained. They are either terrestrial, aquatic, or marine. Many of them are parasitic, seldom green, and without stomata."*

"In ferns," says Mr. Francis, "the Frond is in its leafy part thin, veiny, and green. The veins do not extend longitudinally through the leaf in any species, as in the monocotyledons, but diverge in a branched form (dichotomously divided) from the base of the leaf, or from the mid rib; differing, however, from those in dicotyledonous plants in not containing woody fibre, and being uniform in size throughout all their ramifications. . . . . . Ferns

* Botany, in Cab. Cyc. pp. 76—78.

are several years before they come to maturity, until which their essential characteristics are not always obvious. . . . . .

"The circinate vernation, or curling up of the unexpanded frond, which prevails in all the dorsal ferns, is almost peculiar to this tribe and two of their allies, namely, the palmæ and the cycadeæ. If the frond is simple, so is the vernation; but when the frond is subdivided, the vernation becomes equally compound, the larger divisions first opening, and, by degrees, the branches, pinnæ, and lobes."*

To these general descriptions of the folliaceous appendages of Cryptogamic plants, we shall add a more particular account of those of each ORDER, from the work, already so often referred to, by Sir William Jackson Hooker:—

FUNGI—In the larger sense of the word, the whole may be considered as *fructification*, since distinct from it there is no stem, there are no branches, no leaves, no frond, and very rarely a simple base.

LICHENS—The *Lichens* bear a closer affinity to the *Fungi* than to any other order. Sometimes they are formed of a simple pulverulent crust or frond; sometimes membranaceous, coriaceous, gelatinous, lobed, and variously branched; at all times destitute of leaves.

ALGÆ—Fronds are either gelatinous, filamentous, membranaceous, or coriaceous.

CHARACEÆ—*Stems* slender, confervoid, tubular throughout, pellucid or covered with a calcareous crust, very brittle when dry, and generally fœtid, branched; branchlets whorled, often aculeated. Walloth has given a most admirable account of the fructification of this curious tribe of plants, from which it appears evident that it has no claims to be ranked among the perfect plants, and that its nearest affinity is with the *Confervæ* and *Ulvæ* among the *Algæ*.

HEPATICÆ—*Minute plants* frequently frondose, sometimes (as in *Jungermannia)* folliferous; the leaves often divided, never really nerved.

MUSCI—Bearing leaves which are very rarely indeed divided, often nerved, entire, or toothed, or serrated to the margin.

* British Ferns, p. 4.

FILICES—There is, usually, a subterraneous horizontal *stem* or *caudex*. *Fronds*, before expansion, circinate; they are simple and entire, or variously divided and branched, and cut into *lobes* and *segments* or *leaflets*, of various forms. *Substance* varying from membranaceous to coriaceous.

LYCOPODINEÆ—*Leaves* small, undivided, numerous, scattered, or alternate and distichous, often stipulated.

MARSILIACEÆ—'Isoetes.' *Leaves* all radicle, 5—6 inches long, subulate, semi-cylindrical, fleshy. 'Pilularia.' Leaves 2—3 inches long, subulate-filiform, clustered.

EQUISETACEÆ—Stems rigid, leafless, jointed, striated, the articulations sheathed at the base; the branches whorled.

NAIADES—Floating herbs with very vascular leaves and stems.*

These extracts demonstrate evidently that we are now treating of a group of plants whose leafy expansions are relatively imperfect when we take those of the higher Orders as a standard; and on comparing them analogically with the respiratory organs of the *testaceous* and *conchiferous mollusca*, we find a very close analogy existing between them. These latter are, in a similar manner, defective in pulmonary apparatus, which, in the animal economy, constitutes the point of contact between atmospheric air and the circulating fluids of the higher tribes. The *Cryptogamia* are imperfect in their *folliaceous* appendages, which are the *respiratory* organs of more perfect plants, and the means of communication between *their* circulating system and the surrounding atmosphere; while both, respectively, are provided with modifications of these corresponding organs, in the vegetable and animal existencies, well adapted to execute the functions which devolved upon them under analogous circumstances; in both instances differing materially from the duties which the more perfect orders of either kingdom have now to perform, when the earth has undergone a vast and material change; the modifications alluded to in the construction, and consequently in the functions of both animals and plants, agreeing admirably with the

* Flora Scotica; also British Ferns, and British Algæ.

alteration which, we maintain, took place about the same period in the material universe.

From a corresponding similarity in the organization respectively which thus prevailed in the animals and plants of *the non-rotating period of the Earth's existence*, we may justly infer an analogous object in the design which induced it. This analogy, as a general feature, is very clearly pointed out in a recent standard work on physiology and anatomy.

"The function," say Messrs. Todd and Bowman, "which has for its object the propagation of species, *Generation*, presents many points of resemblance in plants and animals.

"In the former it is cryptogamic or phanogamic; in the latter non-sexual or sexual. In the phanogamic and sexual, the junction of two kinds of matter furnished by the parents is necessary to the development of fertile ova. In the cryptogamic and non-sexual generation, the new individual is developed by a separation of particles from the body of the parent, by which the new formation is nourished only until it has been so far matured as to be capable of an independent existence." . . . . .

And again—

"In plants there is no nervous system; there is no mental phenomena. The motions of plants correspond in some degree with those movements of animals in which neither consciousness nor nervous influence participate. Such movements are strictly organic, and result from physical changes produced directly on the part moved."*

In the case of the *Mollusca*, by the imperfection of their respiratory organs with respect to that which surrounded them, and a corresponding facility of disposing of inhaled elements *internally*, together with their independence of atmospheric air, it was designed—as in reality it was accomplished—to facilitate the formation of carbonate of lime, by abstracting calcium from other acids possessing a stronger affinity for it than carbonic acid, and constraining these two through the agency of the molluscous corium, to unite together in due proportions, and to constitute the innocuous and

* Physiology and Anatomy of Man, vol. i. pp. 25, 27, 28.

insoluble material, *carbonate of lime*, whereby the waters not only were purified from and deprived, to a certain extent, of carbonic acid and of calcium, but the two were safely locked up together in store for future purposes of usefulness; while that which was thus elaborated and constructed, became a secure defence to its molluscous inhabitant against the pressure of the surrounding medium.

It will be seen, when we have developed our plan of argument a little more, that by the imperfection of the leafy expansions of the *cryptogamia* and their independence of light—the great decomposer of carbonic acid in the vegetable economy—it was intended, and did facilitate in like manner, the accumulation of *their* peculiar secretions, not only in themselves, but also by their instrumentality, there were storing up, in the water, elements destined to aid in the formation of the atmosphere, and likewise for more terraine purposes in the sub-soil or strata then forming underneath the primeval ocean surcharged with the corresponding elements. These latter secretions consisted principally of carbon and soda; but were also extended to some others of less general prevalence; while both the solid precipitate and the gaseous exhalation were equally essential for the wants and the comforts of beings which were to be brought into existence subsequently, and for whose wants the Creator was even then providing with that goodness and forethought which characterize all His plans and arrangements.

Our more immediate duties, therefore, are to show *That the imperfect construction of the folliaceous appendages of the Cryptogamia, or of plants resembling them, was designed to produce effects—within the sphere of their action—analogous to those proceeding from the circumscribed and defective respiratory organs of the apulmonic molluscous animals of the same period of the Earth's geological history.* To do this we must again have recourse to the same method which has hitherto been found so successful; although it requires us to pursue what may with propriety be called the differential method of reasoning. We mean that, after having acquired a brief but comprehensive idea of the several divisions of the Vegetable Kingdom, in order to arrive at a knowledge of the

functions of those which existed during the non-rotating period, *and with whose habits and character we can possibly have no direct acquaintance*, we must, first, show the result of an opposite state of matters on plants differently constituted, and then, by inference, deduce the effects likely to have taken place by the action of the imperfectly formed cryptogamia, under the supposed circumstances of the Earth at the time to which we allude; and, by way of confirmation, afterwards compare these deductions with established facts. Having already acquired a knowledge of the principal effects produced on vegetation by the action of the sun's rays, we must now direct the attention to another result, no less important, which proceeds from the influence of LIGHT.

Dr. Roget, in his Bridgewater Treatise, says—

"An important chemical change is effected on the sap of plants by their leaves when they are subjected to the action of light. It consists in the decomposition of the carbonic acid gas, which is either brought to them by the sap itself, or obtained directly from the atmosphere. In either case its oxygen is separated, and disengaged in the form of gas; while its carbon is retained, and composes an essential ingredient of the altered sap. . . . . .

"The remarkable discovery that oxygen gas is exhaled from the leaves of plants during the day-time was made by Dr. Priestly. To Sennibier we are indebted for the first observation that carbonic acid is required for the disengagement of oxygen in this process, and that the oxygen is derived from the decomposition of the carbonic acid. . . . . .

"It is in the green substance of the leaves alone that this process is conducted: a process which, from the strong analogy that it bears to a similar function in animals, may be considered as the respiration of plants. The effect appears to be proportionate to the number of stomata which the plant contains.* . . . . . Neither the roots, nor the flowers, nor any other part of the plant which have not this green substance at their surface, are capable of decomposing carbonic acid gas. They produce, indeed, an effect which is in some respects the opposite of this; for they have a tendency

* It is worthy of observation that Dr. Roget mentions in a previous page of his work (vol. i.) that stomata are never found in the leaves or stems of submerged plants, nor even on the under surfaces of the leaves of aquatic plants.

to absorb oxygen, and to convert it into carbonic acid, by uniting it with the carbon they themselves contain. This is also the case with the leaves themselves whenever they are not under the influence of light. . . . . . This reversal at night of what was done in the day may, at first sight, appear to be at variance with the unity of plan which we should expect to find preserved in the vegetable economy; but a more attentive examination of the process will show that the whole is in perfect harmony.*

"The function by which the fluids are thus ærated," according to Messrs. Todd and Bowman, "is called *Respiration.* In plants the introduction of atmospheric air conveys nutriment to the organism; carbonic acid and ammonia are thus introduced; the former is decomposed, its carbon is assimilated, and its oxygen is exchanged for a fresh supply of atmospheric air. As the agent in the decomposition of the carbonic acid is light, it is evident that the generation and the evolution of oxygen can take place only in the day-time. Consequently, during the night, the carbonic acid, with which the fluids of the plant abound, ceases to be decomposed, and is exhaled by the leaves. Hence plants exhale oxygen in the day-time, and carbonic acid at night.† . . . . .

"When the food of a plant enters the roots," observes another writer, "it passes upwards, undergoing some chemical change, and dissolving whatever soluble matters it meets with in its course; so that, without having been exposed to any of those conditions by which it is ultimately and principally affected, it is considerably altered from its original nature before it reaches the leaves.

"It has already been remarked that a portion of the water which plants suck up, combines with the tissue and enters into the general constitution, where it becomes fixed, as the water of crystallization in minerals. This apparently takes place in the course of the ascent of the sap, before the latter reaches the leaves and becomes exposed to that sort of decomposition and alteration which is here called digestion, and with the phenomena attendant upon which we are best acquainted. . . . . . What we find it most necessary to insist upon in this place, are the three following axioms, to which the experiments of careful observers and skilful reasoners have led: 1. *The quantity of water lost to a plant by evaporation and its power of absorption from the soil, is in proportion to the quantity of Light;*

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* Dr. Roget's Bridgewater Treatise, vol. ii. pp. 29—33.

† Physiology and Anatomy of Man, vol. i. p. 24.

2. Light causes a decomposition of the carbonic acid of vegetation; and, consequently, by solidifying the tissue, renders the parts most exposed to it the hardest; 3. The digestion of plants chiefly consists in a loss of water by evaporation, and in an acquisition of carbon, by the decomposition of carbonic acid. . . . . .

"From these experiments of M. de Candolle it may seem proved that the action of solar light is the great exciting cause of suction at the one end, and of evaporation at the other end of a plant; and that in the night-time plants gain weight, while they lose it in the day-time. Is it not, however, clear that, to speak rigorously, although we may talk of light as being the sole cause of these phenomena—is it not rather the dryness of the atmosphere, caused by the heat of sun-light, as compared with the moisture of the air in the absence of the sun? Thus, in a dry sitting-room, to which the sun has no access, plants undoubtedly perspire by their leaves and absorb by their roots, more than if they were exposed to the sun in a moister atmosphere."*

Professor Henslow also says—

"Light is, as we have seen, the chief agent in stimulating the vital properties of plants, and its effects are apparent in a great number of their phenomena, such as the absorption of the sap, the exhalation of moisture, and the decomposition of carbonic acid."†

The evidences for the *thirty-sixth* Theorem bear particularly upon the point now under consideration; we shall, therefore, direct the attention to some of them, although they may have been already referred to: merely reminding our readers, as regards the Theorem itself, that it goes to prove, in consequence of the great size of the fossil flora, and magnitude of the fossil shells, that there must have existed where they grew and lived a much higher temperature than even now within the tropics. That it seems to have been alike prevalent everywhere, and that the waters must have contained a greater proportion of carbonic acid than what the seas now do.

"Geologists," observes Sir Henry de la Beche, "have discovered

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* Botany, in Library of Useful Knowledge, pp. 84, 85.

† Botany, in Cab. Cyc. p. 298. See 44th and 120th Theorems.

that the superficial temperature of the earth has not always remained the same, and that there is evidence of a very considerable decrease. This evidence rests on the discovery of vegetable and animal remains entombed in situations where, from the want of a congenial temperature, such animals and vegetables would now be unable to exist. Undoubtedly this inference rests on the supposed analogy between animals and vegetables now existing, and those of a similar general structure found in various rocks, and at various depths beneath the earth's surface; but as we now find every animal and vegetable suited to the situations proper for them, we have a right to infer design at all periods, and under every possible state of our earth's surface; and therefore to consider that similarly constituted animals and vegetables have, in general, had similar habitats. . . . The vegetable remains are often of considerable size. M. Brongniart observes that in the coal strata of Dortmimd, Essen, and Bochum, stems are found in the planes of the strata more than fifty or sixty feet long, and that they may be traced in some of the galleries for more than forty feet without observing their natural extremities. Vegetables of large size have also been detected in Great Britain. Mr. Witham mentions one in Cragleith quarry as being forty-seven feet in length from the highest part discovered to the root. The bark is described as converted into coal. . . . . .

"According to M. Adolphe Brongniart, if we look at the arborescent ferns and the mass of the other plants, we must consider the vegetation of the carboniferous group to have been produced in climates at least as warm as those of the tropics; and, as we now find plants of the same class increase in size as we advance towards warm latitudes, and as the coal-measure plants exceed the general size of their existing congenors, he concludes with much apparent probability that the climates in which the coal plants existed were even warmer than those of our equinoctial regions."*

Professor Henslow, in treating of the fossil flora of the ancient world, says—

"Judging from analogy, from the character and relative proportions of the species of different classes, the temperature of those parts in which the plants of the first period were growing must have been both hotter and moister than the climates in any part of the earth

* Manual of Geology, pp. 6, 429, 431.

at present. It has been plausibly conjectured that the atmosphere was more charged with carbonic acid at these early periods of our planet's history, when gigantic species of cryptogamic plants formed the main feature of its vegetation. . . . . . Since the fossil plants, which have been found in the arctic regions, are analogous to those which now grow in tropical islands, it seems likely, that not only must they have enjoyed a higher temperature, but also a more equable diffusion of light than those regions now possess."*

The following concurring evidence is from the standard work on Fossil Botany, to which we have already so frequently had occasion to refer:—

"Up to this time"—that of the formation of the lias and oolitic group—"the features of ancient vegetation were exclusively extra European and chiefly tropical; but immediately succeeding the *chalk* a great change occurred, and a decided approach to the flora of modern days took place in some striking particulars. . . . .

"It is a very remarkable fact that in former ages the range of the species of plants was far more extensive than at the present day. . . . . . M. A. Brongniart assures us that the plants of the North American coal mines are for the most part perfectly identical with those of Europe, and that they all belong to the same genera; the same is stated of fossils from Greenland and from Baffin's Bay. That ours are very much the same as the rest of Europe is certain.

"And, therefore, a *Fossil Flora* of Great Britain applies not only to the rest of Europe, as might have been expected, but also to very distant countries."†

Having so recently brought forward Mr. Miller's remarks on the general suffusion of heat over the Earth's surface during the early period alluded to, and cited his popular illustration of a "universal green-house," we need here only remind our readers of his concurring testimony.‡

"Of the decrease in temperature of the Northern hemisphere," observes Mrs. Somerville, "there is abundant evidence in the fossil

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* Fossil Botany, Cab. Cyc. p. 313.

† Lindley and Hutton, vol. i. pp. xi. xxiii.

‡ Old Red Sandstone, pp. 197, 198.

plants discovered in very high latitudes, which could only have existed in a tropical climate, and which must have grown near the spot where they are found, from the delicacy of their structure and the perfect state of their preservation. This change of temperature has been erroneously ascribed to an excess in the duration of spring and summer in the Northern hemisphere, in consequence of the eccentricity of the solar ellipse. The length of the seasons varies with the position of the perihelion of the earth's orbit. . . . . . In the present position of the perihelion, spring and summer, North of the Equator, exceed by about eight days the duration of the same seasons south of it. And 10,492 years ago, the southern hemisphere enjoyed the advantage we now possess from the secular variation of the perihelion. Yet Sir John Herschel has shown, that by this alteration neither hemisphere requires any excess of light or heat above the other; for, although the earth is nearer to the sun, while moving through that part of its orbit in which the perihelion lies than in the other part, and consequently receives a greater quantity of light and heat, yet, as it moves faster, it is exposed to the heat for a shorter time. In the other part of the orbit, on the contrary, the earth being further from the sun, receives fewer of his rays, but, because its motion is slower it is exposed to them for a longer time. And as in both cases the quantity of heat and the angular velocity vary exactly in the same proportion, a perfect compensation takes place. So that the eccentricity of the earth's orbit has little or no effect on the temperature corresponding to the difference of the seasons."*

Mr. Lyell says—

"That the climate of the Northern hemisphere has undergone an important change, and that its mean annual temperature must once have resembled that now experienced within the tropics, was the opinion of some of the first naturalists who investigated the contents of ancient strata. Their conjecture became more probable when the shells and corals of the secondary rocks were more carefully examined; for these organic remains were found to be intimately connected by generic affinity with species now living in warmer latitudes. . . . . . When the botanist turned his attention to the specific determination of fossil plants, the evidence acquired the

* Connexion of the Sciences, pp. 85, 86. See also 2nd Theorem.

fullest confirmation, for the flora of a country is peculiarly influenced by temperature; and the ancient vegetation of the earth might more readily than the forms of animals, have afforded conflicting proofs, had the popular theory been without foundation. When the examination of animal and vegetable remains was extended to rocks in the most northern parts of Europe and North America, and even to the Arctic regions, indications of the same revolution in climate were discovered."

A little further on he continues—

"We may select the great Carboniferous series, including the transition and mountain limestones, and the coal, as the oldest system of rocks of which the organic remains furnish any decisive evidence as to climate. We have already insisted on the indications which they afford of great heat and uniformity of temperature, extending over a vast area, from about 45° to 60°, or, perhaps, if we include Melville Island, to near 75° North latitude."*

These evidences prove the fact of the general belief entertained, in consequence of the size and other appearances of the vegetable remains, of the universal prevalence of a temperature, in the original ocean, much exceeding that of the present seas; and that, too, for a long but indefinite period, during which, according to this Theory, the Earth was unillumined by the rays of the Sun. All that can be brought forward to explain this seeming anomaly will be carefully adduced in its proper place; meantime it will be sufficient for our present purpose that we have established it to be the prevailing belief, "*That the temperature of the primitive ocean, throughout its whole extent, was as great as that which at present prevails within the tropics, or perhaps greater, and that it contained a larger proportion of carbonic acid gas than is, at present, consistent with animal life.*"

By these incontrovertible evidences we are shut up into a position from which, at first sight, it appears rather difficult to escape; for by them it has been shown, 1st, That *Light, Heat,* and a *moderate* degree of *Moisture* are the essential requisites for the increase of the objects forming the present

* Principles of Geology, vol. i. pp. 105, 106, 145.

Vegetable Kingdom. 2nd. That during the formation of the older strata there grew and propagated innumerable gigantic plants; a fact which necessarily implies the simultaneous and abundant prevalence of what are considered the essential requisites for enabling them to do so; while, in opposition to this, although we willingly admit the existence everywhere throughout the strata—as shown by their vestiges—of immense cryptogamic and other allied plants during the period alluded to, we deny the presence of *Sun-light*, maintain the existence of a universal circumfluent ocean, and the presence of considerable surface warmth. The difficulty of escape from this apparent dilemma is not in any degree lessened when we appeal to writers on kindred subjects, for we find, that, as a combination of this kind has never been anticipated, very little can be gleaned from their writings bearing directly on the subject. Nevertheless, we must endeavour to grope our way, in the hope that these seemingly conflicting evidences may only be fences to prevent us from straying, and, eventually, to lead us to the truth. What, then, do the assertions which have been made on this subject by botanical writers amount to?

We find it stated by one of them—

> "That the quantity of water lost to a plant by evaporation, *and its power of absorption from the soil, is in proportion to the quantity of light;*" and "*That the action of solar light is the great exciting cause of suction at the one end and of evaporation at the other end of a plant.*" Although it is not absolutely denied, "*that these phenomena may not be produced rather by the dryness of the atmosphere, caused by the heat of sun-light, as compared with the moisture of the air in the absence of the sun.*"*

But let the circumstances to which these announcements have reference, and the ends designed to be effected by them, be alike duly considered. They apply to plants growing on Soils, prepared during the lapse of ages for their reception, with depth and consistency sufficient to uphold them throughout every vicissitude of the atmosphere, and which contain the requisite salts and other materials for their nourishment; for

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* Botany in Lib. of Useful Knowledge, pp. 84, 85, and p. 278 of this work.

enabling them to obtain their full vigour, and to display all their natural attractions. They are, in fact, the conditions of soil, light, and atmospheric elements adapted to form and sustain those beautiful and useful vegetable expansions of the earth's surface; destined, while they attract by every elegance of form, to prepare inert matter for the sustenance and the support of animal and rational life, which, without their intermediate agency in the elaboration of crude matter, would cease to exist. Contemplated in these, which are their true points of view, they manifest the wisdom of the plan which, when such is their design, did place the efficient cause of their absorption, vegetation, and increase in a luminary far beyond the earth; by which means that which is to be formed—the vegetable substance—is intermediately placed between the source of nutrition and the absorbing power, between the soil and the sun, and surrounded besides by a fostering atmosphere impregnated with elements suitable for assimilation; while the immense proportional distance, by conferring parallelism on the influencing power, the rays of light, causes perpendicularity of position, and equality of effect.

These, therefore, *are the attendant conditions of the vegetable kingdom of the present day*, and all the relative circumstances are in perfect harmony with the design for which they were called into being. *They*, consequently, could not have existed under a totally different state of matters, which must be inferred to have prevailed during *the period of non-rotation.* But if the actual vegetable kingdom be, in every respect, suited to the earth, the air, and the sun-light, we have a right to conclude, that the plants of the primeval world, before those conditions existed, would, in like manner, be adapted to the attendant circumstances of the earth at that time. If in place of the soil being there for their support and sustenation, it was, itself, to be deposited, they would be independent of it, or, perhaps, instrumental in accumulating it. If there was *no* atmosphere, but, on the contrary, a deep surrounding fluid, it is natural to suppose they would not require the former, and be capable of deriving nourishment from the latter; and that while as yet there were no rays of bright sun-light to excite the several functions of air-breathing plants, those that existed

in the "darkness" would be wholly indifferent to the sun's enlivening influences.

When we more narrowly scan, with an unbiassed and comprehensive view, what appears, from the revelations afforded by the researches of geologists, to have been taking place at the bottom of the primitive water, while as yet "the Earth was without form and void, and darkness was upon the face of the deep," we find these anticipations to be completely borne out; for if we turn for a moment from the consideration of the Earth and its vegetable covering in their present state of perfection, to enquire whether the same reasoning will hold good, or if the same application of means would have suited, had they been directed to the submarine vegetation of the primeval world, we shall find, with regard to it, that in place of the soil having been perfected for the growth of the plants, these, imperfect as they were, appear to have been the means employed to form the carboniferous deposits, by acting as absorbents on the surrounding medium, and elaborating, by their vegetable chemistry and vitality, the earthy ingredients which the waters held in solution, whereby they contributed towards the formation of the carbonaceous and alkaline deposits by those peculiar secretions which they alone could supply; and, further, by disturbing the equilibrium of the ocean they accelerated the deposition likewise of other earthy matter; and, indeed, the debris of the strata which they mainly aided to form, contributed the principal ingredients of the soil employed at present in cultivation!

Indeed, so concurrent is the prevailing opinion, on this point, as regards Algæ, that many seem to think that plants of this order derive the whole of their nourishment from the water by means of their general surface, the roots serving no other purpose than to attach them to the rocks on which they grow. Or, in some cases, still more independent of their radicle terminations, as the widely extended masses of gulf-weed, a species of *Sargassum*, which, hitherto, has never been found attached by roots.

Those ends having been manifestly held in view, the wisdom and adaptation of the arrangement are made evident by the Creator having ordained that "Darkness should be on the face

of the deep;" because "*Light being the great exciting cause of suction at one end of a plant, and of evaporation at another,*" Light would have been inimical to the whole scope of the operations then in progress. On the contrary, what was required, and, consequently, what was in operation, was an influence which should stimulate the plants in a direction *opposite* to that in which the sun-light is now known to act upon them, and thereby to occasion an active absorption from the surrounding fluid through their organization, whereby they might appropriate and afterwards assimilate in themselves the nutritious ingredients with which the water was charged; so that in place of that which should be absorbed being derived, as it partly is at present, from the soil, it should be abundantly abstracted from the surrounding water, and, by vegetable chemistry, be locked up in the strata, for the future uses and necessities of the world's inhabitants; while the waters themselves should, by the same agency, become simultaneously prepared to perform *their* important part, also, as the seas of the present day.

This view of the case receives considerable confirmation when we reflect, 1st. That there positively did grow in the ancient water gigantic plants, either of the *Cryptogamic orders*, or closely allied to them; the fossil vestiges which remain proving this by the evidence of the senses. 2nd. That these plants could have been in contact with only two distinct substances, or bodies, namely, with the soil and with the water. And 3rd. That they were, themselves, chiefly the means of forming the soil; consequently, as there was little preparatory soil, and the plants are admitted to have grown, and to an immense size, there is no alternative left but to conclude, that as their principal means of subsistence was *not* in the *soil*, it *must have been in the water:* we mean, in a degree analogous to the sustenance which plants of the present day derive respectively from the earth and from the atmosphere.

If such was the case (and we hardly know how it can be doubted), we should, on investigation, discover a peculiarity of structure in those ancient submarine plants which would adapt them to perform their peculiar functions with an effect analogous to what recent trees and plants are enabled to

do through their roots and folliaceous appendages. In place of finding comparatively slender stems and wide spreading roots to support them in the ground and to afford them the requisite nourishment, we should discover trees and plants with their outer surfaces widened by every possible contrivance, punctured by absorbing apparatus as the means of imbibing from the surrounding waters, whose stems, in place of spreading out into boughs and branchlets, and being covered with thin and delicate leaves and decked with flowers, should be less ramified, and furnished with other analogous and useful appendages equally well adapted to the element in which they grew, and not being subject to the viscissitudes to which trees growing in the atmosphere are exposed by its sudden and violent movements, and which are, on that account, provided with roots to uphold them against the winds—those submarine plants should be furnished with roots much less in proportion to their stems, and by no means so wide spreading, as the still tranquil ocean of the primitive world never exposed its vegetable inhabitants to similar trials, but on the contrary sustained them while they grew, at the bottom of its dark waters, and enabled them to perform their part in the development of the plan of creation.

The following extracts confirm this so completely, that, although somewhat long, we cannot refrain from quoting them:—

"The *Tree-ferns* of the tropical regions exhibit several characters by which they may be compared with the ancient plants dug up from our coal mines. When Dr. Martins saw the first specimens of *Polypodium Corcovadense*, so remarkable for the tesselated surface of its *caudex*, he was struck not only with the novelty of the circumstance, but immediately called to mind the figures of certain petrified forms described by Sternberg under the name of *Lepidodendron;* on comparing which, with the stems of eight arborescent species collected in his journey, he found them connected by so intimate an affinity, that he could entertain no doubts of their generic identity, and was convinced in fact that their characters were perfectly concordant. . . . . .

"The *Filicites quadrangulatus*, called *palmacites quadrangulatus* by Schlotheim, occurs in the older coal formation, at the coal mines of

Opperoda, and Manebach. It corresponds with the stem of the *polypodium corcovadense*. . . . . . Almost all writers agree in representing the family of *Palms* as having existed among the first vegetables, and as being frequently found buried along with the other fossil remains. Nor is it to be doubted, says Martins, that their remains, viz., the stems, fronds, and fruits occur in the older coal formation, although they are much less frequent than is commonly believed, the arborescent ferns having been frequently taken for them. . . . . .

"Various genera of *arborescent grasses*, allied to the *Bambusia*, seem to have been much more frequent than palms in our antidiluvian plains. To these fossil plants the older writers applied the name of *Calamites*. They are now referred to *Equisetums* by Mons. A. Brongniart. The *Caciphoræ*, *Dracænæ*, *Pandani*, *Yuccæ*, and *Vellosiæ* constitute another tropical series allied to the palms, which also make their appearance among our primeval plants. The marks by which they may be distinguished are chiefly connected with the circumstance, that the stems are invested all round with the semi-amplexicaul base of the leaves which remain after the upper parts have fallen off, and hence they resemble a surface covered with imbricate scales, spirally arranged in various ways, according to the various disposition of the leaves. It appears that the scales being imbricated upwards are not distinct from each other in their whole extent, and therefore may easily be distinguished from the scales of Filicites, so called. . . . . There exist in our coal mines numerous examples of petrified forms, frequently several feet long, remarkable for tubercules or polygonal impressions distinct from each other, and longitudinally disposed in straight lines, separated by parallel grooves or ridges, and marked with a simple cicatrix impressed in the specimen itself upon the carbonaceous bark, but elevated in the impression or cast. These vegetables belong to the genus *Cacti*, all shrubs of warm climates, and are called *Cactites* . . . . A genus of fossils described by Count Sternberg, under the name of *Syringodendron*, agrees in many of its characters with the *Cactites*, nor can it be doubted that it belongs to the succulent, or fig tribe of vegetables.

"There is a very remarkable fossil, with branches attenuated upwards, and having the whole surface covered with leaf-bearing scales, arranged in an imbricated manner, neither referable to the genus *Yucca* nor to that of *Cactus*, to which Sternberg has given the name *Lepidodendron dichotomum*. . . . . .

"With regard to this plant, as well as the preceding genera, it deserves to be remarked that, like ferns, they are all vegetables furnished with a singular structure of organs subservient to respiration, and highly adapted for inhaling nutritious juices from the atmosphere. It is well known that the *Cacti*, as well as most succulent plants, derive their nourishment more from their relation to the air than to the Earth. The *Yuccæ* and *Lychnaphoræ* which choose for their habitation a dry, sandy soil that has undergone little preparation from the decomposition of previously existing vegetables, were peculiarly adapted for clothing a recently formed world much warmer than the present. By such plants, vegetable matter would rapidly accumulate to the extent that we find in our coal strata."*

What has now been said, together with the evidences which have been adduced, will, we trust, be sufficient to show the adaptation of the primeval plants to the primeval condition of the world; and, thereby, to convince us that only as they then existed could they have performed the object, and wrought out the design of their being. We have still, however, some points to look into before we dismiss this part of our subject altogether. We have to endeavour to explain how the decomposition of the carbonic acid and the fixation of the carbon took place; and to show, if possible, what became of that which was not decomposed, and of the other materials which may be supposed to have been imbibed by those plants, deprived, as they were, of sun-light to cause decomposition and exudation, and stinted, as most of them appear to have been, in folliaceous appendages. This undertaking is by no means easily accomplished; and in attempting it we are met, at the very outset, by rather an imposing difficulty, arising from the seeming incompatibility of some of our positions with admissions which are considered to be equally tenable. Not the least formidable of these consists of the following:—

The denial, on the one hand, of the existence of sun-light, the great decomposer and solidifier of ligneous material. On the other, the fact that *Coal* not only is of vegetable origin, but, as appears by the fossil vestiges found intermingled in the

* New System of Geology, pp. 445—450.

formations, that it must have accumulated from plants *which acquired enormous magnitude*, while, at the same time, it is an axiom in Botany, *that the amount of the decomposition of carbonic acid and the fixation of woody matter take place in direct proportion to the quantity of light;* or, as expressed by writers on those subjects, "Light causes decomposition of the carbonic acid of vegetation, and, consequently, by solidifying the tissue, renders those plants the hardest which are most exposed to it."*

The only explanation, in the present state of our information, respecting those arcanæ of the primeval world which we can offer is, that the fixation of carbon in forming the woody fibre, having reference principally to that which takes place in the plants of the *Dicotyledonous* and *Monocotyledonous* classes, while the whole scope of our argument rests on the assumption *that the older Coal formations originated in submerged Acotyledons, or plants similar thereto*, it becomes a question, whether these objections, or any that may arise from the ascertained functions of the other two classes, ought to be admitted against the latter, even supposing it to be satisfactorily established that the chemical gradation is uninterrupted between the lignites which proceed from *Monocotyledonous* and *Dicotyledonous* plants, and the coal of the older formation; which, although evidently of vegetable origin, yet arose, as we have so frequently insisted upon, from the accumulation of plants whose character and habits show them to have been closely allied to cryptogames, one of whose chief characteristics is indifference to LIGHT.

In following up this subject, therefore, it will be necessary, before making any further enquiries into the disposal of the carbonic acid, and the fixation of the carbon, to ascertain by which part of the vegetable economy the former is considered, by botanical physiologists, to be elaborated.

"The formation of carbonic acid," says Professor Henslow, "takes place in the leaf, beneath the epidermis; but whether the air penetrates through the stomata or not is still uncertain. That

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* Botany in Library of Useful Knowledge, p. 85. See the whole passage included between pp. 85—87.

it cannot be universally introduced through these organs is apparent, since many leaves have no stomata; and in these cases, at least, the action takes place through the intervention of the delicate membrane, of which the vescicles of the cellular tissue are composed. If a section perpendicular to both surfaces of a leaf be examined under the highest powers of the microscope, the interior will be observed chiefly made up of cellular matter, or 'parenchyma,' whose vescicles are loosely aggregated, so that large intercellular passages exist in communication with each other through its whole substance. That these passages are filled with air is readily shown by placing a leaf under water, and beneath the receiver of an air-pump. Upon exhausting the receiver, the air contained in the leaf will be seen to escape through the petiole; and upon removing the receiver, the water will then find its way into the leaf, and occupy the interstices which were originally filled with air. . . . .

"At present so little has been ascertained of the conditions under which this air has been introduced into the vessels, or of the peculiar office which it is destined to perform, that we can do no more than just mention the fact, and state the opinion of some botanists, who have considered it probable that in these situations also it is subservient to the process of respiration, and who conclude that it is not impossible there may exist a strong analogy between the manner in which this function is performed by plants and by some of the inferior tribes of animals."*

If, therefore, it be the case that the leaves elaborate carbonic acid, it follows, *that the more reduced the size of the leaf, and the more inperfect its structure, the less will be the formation of carbonic acid; and, consequently, the less the necessity of decomposition and exudation.* And, as it has been already shown, from undoubted authority, that the whole of the Orders and Genera which compose the *Acotyledonous* class of plants are defective in folliaceous appendages, we have a right to conclude that those operations were by them performed only to a limited extent. In this we enjoy another convincing illustration of the wonderful harmony which prevailed between their conformation and the state of the creation at the period of their existence. *The design was, not to exude, but to retain*

* Botany, in Cab. Cyc. pp. 187, 188.

carbonic acid in the system of the plants, and, therefore, those appendages, which, by decomposing and exuding this acid, would have frustrated that object to a certain extent, and thereby have proved inimical to the design intended, were very feeble in these vegetable elaborators.

Nor should the idea be overlooked which has been suggested above, "That leaves under the circumstances mentioned perform the function of vegetable respiration in a manner analogous to that in which the same operation is carried on in the inferior races of animals;" for the establishment of what is thus so unconsciously admitted, or rather conjectured, is the very point we have been endeavouring, throughout the whole of this section, to establish as one of the principal steps towards the elucidation of the uses made of those vast forests of submerged Acotyledons, which abounded during the period of darkness and non-rotation.

That the mind may be relieved from any doubt which may arise from the idea that an adequate substitute might have been provided to carry on these operations by other parts of the plants, we give the following passage from the botanical writer to whom we have been already so frequently indebted:—

"With regard to plants *not* green, which botanists usually call *coloured*, their function seems to be *to absorb oxygen without fixing it, and they appear to possess no power of decomposing carbonic acid when they have formed it.* Such is said to be the case with roots, old trunks, petals, stamens, ripe fruits, mushrooms, and certain lichens. A part of their carbonic acid escapes into the air, a part is dissolved in their fluids, especially in the roots, whence it passes upwards into the system.*

These opinions, given by physiological botanists, of the process by which carbonic acid is decomposed by living plants, and carbonaceous material becomes fixed in the two higher classes, when applied to the case of *Submerged Acotyledons*, would lead us to conclude that taking their deficiency in the operative organs, and the entire absence of the requisite ex-

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* Botany, in Library of Useful Knowledge, p. 90. Confirmed by Dr. Roget's Bridgewater Treatise, in vol. ii. p. 32.

ternal stimulants into account, they would be found to be remarkable for their paucity of woody fibre throughout the masses of their trunks and branches. The following evidences, taken from the works of geological botanists who have directed their attention to this particular feature of fossil plants, will, we think, fully corroborate this assumption :—

EQUISETACEÆ—Reaches from Lapland to the torrid zone. Latitude seems to have had no effect on the size of fossil equisetaceæ. Calamites (Equiseta) characterised by large and simple cylindrical stems.

FILICES OR FERNS—The most numerous of the vascular cryptogamic plants. In the coal measures about 120 known species, forming one-half of the entire known flora of this formation. . . . The stems of these arborescent ferns are distinguished by certain peculiarities from those of all monocotyledonous plants.

LEPIDODENDRON—With the exception of their great size they very much resemble the *Lycopodiaceæ* or *Club* moss tribe. . . . . The internal structure of their stems is intermediate between these and *Coniferæ*. . . . . After *Calamites* the *Lepidodendron* are the most abundant class of fossils in the English coal formations.

SIGILLARIA—Abound most in the transition series. Are colossal. Stems are generally filled with sand or clay, and supposed to have been without any transverse dissepments, and *hollow* throughout. The bark, which alone remains, probably surrounded an axis composed of soft and perishable pulpy matter similar to that of living *Cactæ*. The stems fluted from top to bottom by an external covering, separable like true bark from the soft internal axis, or pulpy trunk; this is usually converted into pure coal. The remaining characteristics of the *Sigillaria* and allied group of fossil plants, *Favularia*, *Megaphyton*, *Bothrodendron*, and *Ulodendron*, have been so lately given that it would be superfluous to repeat them here.

STIGMARIA—Both surfaces of the external rim of the stem are slightly corrugated. Branches covered with spirally disposed tubercules. The form of the trunks and branches show that they could not have risen up into the air,

but must have either trailed on the ground or floated in water.*

The following corroborative evidence is taken from the Fossil Flora:—

STIGMARIA—(Variolaria, *Sternb.* Mammillaria, *Ad. Brong.* Ficoidites, *Artis.*) Stem originally succulent, marked with roundish tubercules arranged in a direction more or less spiral; internally a distinct woody axis, communicating with the tubercules by woody processes. Leaves arising from the tubercules, succulent, entire and veinless, except in the centre, where there is some trace of a mid rib.

ASTEROPHYLITES—(Bornia, *Sternb.*) Stem scarcely tumid at the articulations, branched leaves verticillate, linear, acute, single mid rib. (Fruit a one seeded (?) ovate compressed nucule, bordered by a membranaceous wing, and emarginate at the apex). *Brong.*

Note. This is probably an extremely heterogenous assemblage, comprehending nearly all fossils, with narrow veinless verticillate leaves, not united in a cup at their base.

BECHERA—Stem branched, jointed, tumid at the articulations, deeply and widely furrowed; leaves verticillate, very narrow, acute, and ribless.

STERNBERGIA—(Columnaria, *Sternb.*) Stem taper, slender, naked, cylindrical, terminating in a cone, marked by transverse furrows, but with no articulations. Slight remains of a fleshy cortical integument.

EQUISETACEÆ and CALAMITES—Stems jointed, regularly and closely furrowed, hollow, divided at articulations by a diaphragm; covered with a thick cortical integument. (? Leaves verticillate, very narrow, numerous, and simple).

LYCOPODITES—Branches pinnated. Leaves inserted all round the stem in two opposite rows, not leaving clean and well-defined scars.

LEPIDODENDRON—(Sagenaria, *Sternb.*) Stems dichotomous, covered near extremity with simple linear leaves. Areolæ, &c.

* Professor Buckland's Bridgewater Treatise, vol. i. pp. 479—481.

ULODENDRON—Stems covered with rhomboidal areolæ. Scars large, few one above the other, composed of broad cuneate scales, radiating from a common centre, and indicating the former presence of organs that were perhaps analogous to the cones of Coniferæ.

SIGILLARIA—(Rhytidolepis; Aveolaria; Favularia; Catenaria, &c., *Sternb.*) Stems conical, deeply furrowed, not jointed, scars placed between the furrows in rows, not arranged in a distinctly spiral manner, smooth, much narrower than the intervals which separate them.*

After perusing these evidences it cannot be doubted that there was the design—which of course was accomplished—of throwing the bulk of the carbonaceous material, which the ancient plants were capable of elaborating, into the exterior rim of their stems and branches.

The element in which they appear to have floated would, while it supplied them with nutriment, very materially contribute to this by upholding their pulpy or semi-hollow bulky trunks, and permitting them to send forth their spirally arranged branches in every direction around them.† The whole arrangements respecting these ancient plants—existing as they did at so early a period of the Earth's history—exhibit another fine example of the admirable adaptation of means to an end which characterises all the handiworks of the Omnipotent.

The evident intention being to create carbonaceous matter by means of the periphery of these huge vascular plants, there was no element by which they could have been better upheld

* Fossil Flora, by Lindley and Hutton, vol. i.

† We consider the spiral arrangement of their branches, leaves, and fronds or cones, which seems to have been general, very strong presumptive evidence of their having floated in water. It is asserted of the *stigmaria* that they either did so, or "*trailed on the ground.*" Had this latter been their habit, would their branches have proceeded in regular order *all round the stems?* Would not the spiral arrangement have been interrupted wherever the trunk rested on the ground? It is maintained from their debility, in comparison with their great size and length, that they must have done the one or the other—the attendant circumstances are adverse to one of the suppositions—that of trailing on the ground; but are in strict accordance with the other. Can there, therefore, be any doubt as to which opinion should be ultimately adopted? We think not.

than water, and there is no imaginable form better calculated to confer strength upon and to increase the extent of the external surface of any cylindrical body whatever than by fluting, that is, by forming it into ridges and depressions parallel to the line of its axis; nor is there any other construction which would enable a plant, in contact with a surrounding fluid from which it was deriving nourishment and support, more effectually to be supplied with both. And, in the instance in question, we find that these means were effectually adopted.

We think, likewise, that we can discover what, with all deference, may be called a degree of mannerism in these arrangements.

In the case of the molluscous and zoophytic agency the object then was to create carbonate of lime for the benificent purposes intended, and this was effected by causing the innumerable forms of these creatures to encrust themselves with ponderous coatings of that stony material.

In the instance we are now more immediately considering, the design seems to have been to create carbonaceous matter (and perhaps to form free oxygen), by an agency in the vegetable world corresponding to the imperfect molluscs of the animal kingdom; and, in carrying this into execution, they were caused to secrete carbonaceous matter throughout the whole extent of their comparatively rigid exterior around a soft and vascular central axis; whereby it is to be assumed that the greatest amount of the destined material could be elaborated in the least possible time, while it conferred relatively the greatest degree of strength to the plant itself.

In continuation of this part of our argument we may remark, that there is every reason to suppose that plants possess the power of throwing off, by their roots, whatever is hurtful to them which may have entered into their circulation. On this point the following quotations are very conclusive:—

"That roots give off, in some cases, a peculiar matter has been known for some time. Brugmans was the first to observe it in the heartsease; and it was afterwards remarked in the elm and some other plants. No one, however, seems to have suspected this to be a general function of vegetation before M. de Candolle, who as long

ago as the year 1805 called attention to this curious subject. It now appears from experiments conducted by M. Macaire, of Geneva, that to throw off excretions by the roots is a general property of plants, and one of their most important vital actions. . . . . . . The faculty, indeed, which plants possess of getting rid of excretions by the roots would seem to be a necessary condition of their life; for if they had not such a power, the fæcal matter which they now part with would be re-dissolved by the ascending sap, and carried back into their system to their own destruction. Macaire showed by a simple experiment that a plant if poisoned will disembarrass itself of the offending matter by its roots, if it has the opportunity. He took a plant of Mercury (*Mercurialis Annua*), and divided its roots into two parcels, one of which he introduced into a weak solution of acetate of lead, and the other parcel into pure water; at the end of a few hours, the water which was originally pure had become imperceptibly impregnated with acetate of lead, which had therefore been taken into the circulation by the roots on one side of the plant, and thrown off again by the roots on the other."*

Dr. Roget, in his Bridgewater Treatise, affords the following confirmatory evidence :—

"It had long been conjectured by De Candolle that the noxious particles contained in the returning sap of plants are excreted or thrown out by the roots. . . . . . The truth of this sagacious conjecture has been established in a very satisfactory manner by the recent experiments of M. Macaire,† by which he 'ascertained that neither the roots nor the stems of the plants he employed when completely detached and immersed in water could produce this effect,' which he therefore concludes is the result of an exudation from the roots continually going on while the plant is in a state of healthy vegetation.

"By comparative experiments on the quantity of matter thus excreted by the roots of the *Phaseolus Vulgaris*, or French bean, during the night and the day, he found it to be much more considerable at night; an effect which it is natural to ascribe to the interruption in the action of the leaves when they are deprived of light, and when the corresponding absorption by the roots is also

* Botany, in Library of Useful Knowledge, pp. 104, 105.

† For an account of these experiments see the fifth volume of the "Memoire de la Societe de Physique, &c., de Geneve."

suspended. This was confirmed by the result of some experiments he made on the same plants by placing them during the day time in the dark, under which circumstances the excretion from the roots was found to be immediately much augmented. . . . . .

"The same fact was also proved by another set of experiments on the *Mercurialis Annua*, the *Seneui Vulgaris*, and the *Brassica Campestris*. The roots of each specimen, after being thoroughly cleaned, were separated into two bunches, one of which was put into a diluted solution of acetate of lead, and the other into pure water in a separate vessel. After some days . . . . . the water in the latter vessel was found to contain a very perceptible quantity of acetate of lead. . . . . . Similar experiments were made with lime water and with a solution of common salt, and were attended with like results. De Candolle has ascertained that certain maritime plants which yield soda, and which flourish in situations very distant from the coast, provided they occasionally receive breezes from the sea, communicate a saline impregnation to the soil in their immediate vicinity, derived from the salt which they doubtless had imbibed by their leaves."*

It now only requires to be ascertained *whether plants which are denied the sun-light contain more carbonic acid than those which enjoy its rays; and if aquatic plants actually deposit carbonic acid from their roots;* and, fortunately, both these points have been established beyond the possibility of a doubt, as will be seen by the following quotations:—

Mr. Murray, writing to the Edinburgh Philosophical Journal, says—

"While in London, last winter, I made a considerable number of experiments on the hyacinth, &c., growing in bulb glasses; the bulb being carefully washed with distilled water, was seated on the glass filled also with distilled water, and the whole covered with a bell glass. In two or three days the water was highly saturated with carbonic acid gas, and this being precipitated with lime-water, potassa, or caustic barryta, afforded a brisk effervescence on the affusion of diluted acid. The immediate *milkiness* which ensued on agitating the fluid with lime water, was proof enough, though it was well to carry the experiment to its ultimatum. In numerous repetitions I found it uniform, and showed it to some of my friends.

* Dr. Roget's Bridgewater Treatise, vol. ii. pp. 45—50.

"By using lime-water much diluted with distilled water, the interior surface and bottom of the bulb-glass were encrusted with minute rhombs of carbonate of lime, perfectly diaphanous.

"From a seedsman in Fleet Street I got a bulb and bulb-glass; the roots had already shot down fibres into the water four or five inches long, and it was fast advancing into flower. The fibres of this plant when I received it were ragged at the tips, and tingent or gaping, and they were also quite transparent. Water had filled these tubes, and given rise to a beautiful phenomenon; for the descent of the air-bells was thus exhibited, and closed the evidence, if further proof had been necessary.

"This fact will certainly tend to explain some apparent anomalies. In experiments made on plants in relation to their amelioration of the atmosphere, contaminated by respiration, wherein no beneficial change [or a bad one] was exhibited, it must be evident that, as carbonic acid is excreted by the roots, the confined atmosphere might be deteriorated by the gas arising from the earth when the soil in which the vegetable grows is saturated. Besides, these experiments may change our views in relation to the phenomena of agriculture, while it will satisfactorily explain the prompt transit of caustic earths into carbonates; and thus may be a hint valuable even to the *geologist*."*

M.M. de Candolle and Sprengel say—

"The exhalation of oxygen gas is closely connected with a remarkable property of leaves, namely, their green colour. As this colour in the rainbow stands exactly in the middle, between the two outermost tints, the red and the violet—as it is bounded on the one side by the yellow and on the other by the blue—as all experiments further show that the red and yellow tints are more of an oxygenous, and the blue and violet more of a hydrogenous nature—it is extremely probable that the green colour is the effect of a neutralization between the two extreme colours, or that it arises, when the light has attracted exactly as much oxygen as was required by the hydrogen and carbon which remained. And this theory seems to be confirmed by the following observations:—All plants so long as they are withdrawn from the light of the sun are of a

* Letter by Mr. Murray, in Edinburgh Philosophical Journal, No. xiv. pp. 329, 330.

pale yellow colour, and regain this same hue when, as in the instance of the Endive and Cardoon, they have been covered with earth and blanched. In this condition they are rich in oxidized juice, as their sweet taste and the tenderness of their parts show. Besides, these blanched plants give out nothing but carbonic acid water, saccharine matter, and mucilage.*"

On consulting any work on chemistry, it will be seen that the *Algæ* produce soda and potash combined with carbonic, sulphuric, and muriatic acids; and we have seen by the remarks of Dr. Roget that marine plants deposit saline substances when placed in circumstances favourable for doing so.

The following direct testimony corroborative of these facts, from a different source, will, no doubt, be perused with interest:—

"In a commercial point of view," says Dr. Landsborough, "our British sea-weeds rise in national importance on account of *kelp* which is made from them. . . . . . When M'Culloch visited the Hebrides in 1818 the total product of kelp from these islands was estimated at 6,000 tons, which, at £20 per ton, must have realized the sum of £120,000. . . . . . We shall pass over the method of making the kelp from *Laminævia digitata, Fucus serratus, Nodosus, &c.*, and follow the *material* to Glasgow, where there are at present twenty establishments, some of them very extensive, for the *lixiviation* of kelp and the manufacture from it of iodine, &c. . . . . .

"The object of the *lixiviator*, as he is called, is to separate the various salts which the kelp contains. The most insoluble are those which are first separated, consisting of the *sulphate of potash*, the *carbonate, muriate and sulphate of soda*, and the *muriate of potash*.

"The most soluble remain in the solution. In the solution the *iodine* and other very soluble salts are found, and it is from them the liquor, called the *mother liquor*, that *iodine* is extracted."†

And with this satisfactory testimony we may close the evidences for this part of our subject, and proceed to sum up what has been said during the present chapter.

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* Elements of the Philosophy of Plants, p. 201.

† History of British Algæ, pp. 60, 61.

We have followed this branch of our general subject through all its windings, until we have reached a point which establishes the fact, that it is a property common to plants to throw off by their roots whatever might otherwise be prejudicial for them to retain; that they likewise deposit carbonic acid by their roots, or accumulate it within themselves when deficient in those radical appendages; and that some of the cryptogamic plants produce carbonic, muriatic, and sulphate of soda and of potash. These evidences corroborate, to a certain extent, the assumption, that the elaboration of carbonaceous matter and the storing of it up for future purposes in certain forms, together with the deposition of some of the stratified masses, were within the scope, and appear to have been the principal objects contemplated, and fully accomplished, by the submerged vegetation during the non-rotating period of the primitive world. Indeed, we have only to take into account the inexhaustible stores of carbonaceous matter which exist in the great coal formations, the large proportion of carbon which enters into the composition of almost all vegetable soils, and the volume of carbonic acid locked up [to be released at pleasure] in the extensive calcareous formations which everywhere abound, to be convinced of the amount of work performed during that protracted period by the instrumentality of vegetable chemistry, the plants which performed it being immersed in the waters of the primeval ocean, whilst "the earth was without form and void, and darkness was upon the face of the deep."

The evident and close adaptation of means to the end, which we recognize in all these arrangements, evinces, in the most undeniable manner, that no other class of plants, *except one which does not correspond with the description of either of those given in the first chapter of Genesis,* could then have existed; for, if any other could have performed the work required, they would have been there associated with the ancient flora; while, in another respect, there is a perfect accordance between this state of matters in the primeval world and the announcements made by the inspired historian, who, evidently cognisant of this fact, omitted to enumerate the *flowerless, seedless, fruitless* plants, when putting on record the creation

of the other two perfect classes.* The knowledge of this as clearly points to the alone source from whence it could have been derived.

Nothing, perhaps, tends more to corroborate the view we have adopted of the *entirely distinct eras* of the creation of the *flowerless, seedless, fruitless,* and of the *phanogamous* plants, than the contrast which is afforded by a comparison between the well-authenticated restriction of the *recent* Flora, of more perfect construction, to foci of creation treated of so much in what is called *botanical geography;* and the universality and equality of the wide-spread and everywhere abounding *cryptogames* of the primeval world. The former, affected by the divergent inequalities of the earth's surface, kept apart from each other, as it were, by insular and continental distances, and bearing the stamp of differences of climate and of soil. The comprehensive command applicable to the whole terraine surface, "Let the Earth produce grass," having, by its climateric zones, been modified into perfect adaptation to each, and thereby having caused distinct foci of vegetation amongst the phanogamous classes. The primeval flora, seemingly indifferent to all these influencing causes, found embedded everywhere, and everywhere alike, so that in the language of M. de la Beche, "there certainly was a similar vegetation about the same period over parts of Europe and North America, which leads to the inference, that there was a similar climate over a large portion of the northern hemisphere, such as we have not at present, for it was at least tropical, if not ultra-tropical;" and this Messrs. Lindley and Hutton fully corroborate when they offer the following cogent reasons as a general recommendation of their admirable work, the Fossil Flora:—

"In another point of view, we think," say they, "a work of this kind is likely to be of general utility. It is a remarkable fact, that in former ages the range of the species of plants was far more ex-

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* We beg to be clearly understood: we mean by this all plants not included in the description given, "The herb yielding seed, and the fruit-tree yielding fruit, whose seed is in itself upon the Earth," each after their respective kinds.

tensive than at the present day. The plants of the North American coal mines are, for the most part, perfectly identical with those of Europe; they all belong to the same genera. The same is the case with fossils from Greenland and from Baffin's Bay. Ours are very much the same as those of the rest of Europe, and, therefore, a Fossil Flora of Great Britain applies not only to Europe generally, but also to very distant countries."

And, altogether, confirm us in the belief, that one set of effects are produced by the *phanogamous* plants having been created *after* the Earth had, at the hand of God, assumed its actual diversity of form, and present vicissitudes of climate, while another and an altogether different set of effects arose from the no less certain cause of the earth having, when the ancient flora existed, been *a sphere of non-rotation, surrounded by a dark and atmosphereless ocean,* where no difference of climate or change of season were ever known; but being one vast range of level surface, under the same omnipotent and fostering care, the plants now found fossil were equally produced wherever necessary over its whole extent; nurtured until they assumed their indicated magnitude, and caused to perform important offices in the formation of the strata, and in the purification of the waters.

With these observations we shall bring this section of our work to a close; believing that what is contained in it has advanced us another step towards the unfolding of our prefatory assumption, "*That during the period referred to, there were being formed, under the primitive ocean, by the combined instrumentality of chemical and electrical agency, and of animal and vegetable secretion, those materials which were afterwards, when raised from their recumbent position by centrifugal impetus, to constitute an important part of the earth's geological formations and meteorological phenomena, while, simultaneously, the ocean was undergoing due preparation for becoming the seas of the present time.*"

SECTION IV.

DEPOSITION OF THE STRATA DURING THE NON-ROTATORY PERIOD.

CHAPTER VIII.

The subject of argument of the present Section succinctly stated. Deposition of the stratified masses. Proof that the materials which compose the strata existed in the primeval ocean. The Earth accurately weighed before the deposition commenced, and after it ceased, and found, in either case, to be the same. In continuation, several sources of doubt respecting the origin of the strata removed, and clearly shown that underneath the stratified masses of the Earth's crust there is an impervious base of amorphous crystalline rock. Order of superposition laid down, in accordance with the classification of M. de la Beche. Table given, and corroborated by general extracts. Wherever the surface of the Earth has been geologically examined it is found to have been, at one time, submerged in the waters of the ocean. And, in conclusion of this Chapter, that all stratified rocks afford evidence of having been deposited from water.

Having thus shown, in the preceding Sections, that there existed in the primitive ocean, before "the separation of the waters and the dry land," successive tribes of creatures and of plants which were made use of to secrete the peculiar ingredients necessary alike for the meteorological elements and for the perfection of the stratified masses, it now becomes necessary to endeavour to elucidate the manner in which we consider that these strata were deposited from the ocean in which the inferior animals and plants were thus engaged, while fulfilling their appropriate destinies. To relieve the argument from all unnecessary complication no direct allusion shall be made for the present, either to the Conglomerates and Breccias, nor to the Unstratified Formations—under pledge of resuming those

points hereafter. Our attention will be principally directed to the deposition of the strata, with only such occasional allusions to the others as are indispensable.

The first step to be taken in this inquiry is to become assured *that the materials which contributed to the formation of the strata actually did exist in the water then surrounding the nucleus of the Earth;* for, unless we succeed in doing this, all the reasoning which may be founded hereafter on its assumption will be uncertain and inconclusive; while, on the other hand, if established, as we trust it shall be, our future arguments will be greatly confirmed and strengthened.

Let it, then, be supposed, that, before any deposition whatever had taken place, the whole Earth had been accurately weighed, and the weight noted down; that, after a lapse of ages, when we come to examine its surface, we should find certain concentric layers of strata surrounding it in every direction, bearing evident symptoms of having been deposited from a fluid which had held them in solution and suspension; that we should be assured the greatest part of these did not derive their origin either from the comminution or the disintegration of other rocks; that we should be made aware of the existence *underneath* the secondary strata of a continuous hard shell or crust, from *within* which the strata could not possibly have come; and that we should now witness an immense body of water, clear and pellucid, containing little or no earthy matter, washing those stratified masses in their upheaved position; and then let it be further supposed that the terraqueous globe, after all these changes had taken place in both of its portions, was again placed in the same balance and found to have neither lost nor gained a single apice in weight; that it remained precisely the same as it was at first; it would seem natural and just to infer therefrom, *that the materials of the stratified masses* DID *exist in the turbid primeval waters, from whence they were deposited, leaving them pellucid and sparkling as they now are;* and it shall be our care to show, that all these presumed circumstances are correct, and capable of bearing whatever superstructure may be raised upon them.

It will be observed by the *seventieth* Theorem, *that the*

law of gravitation is in direct proportion to the mass, and inversely as the square of the distance. It is stated by an accomplished writer on this subject to be

"A singular result of the simplicity of the laws of nature, which admit only of the observation and comparison of ratios, that the gravitation and theory of the motions of the celestial bodies are independent of their absolute magnitudes and distances. Consequently, if all the bodies of the solar system, their mutual distances, and their velocities, were to diminish proportionally, they would describe curves in all respects similar to those in which they now move; and the system might be successively reduced to the smallest sensible dimensions, and still exhibit the same appearances."*

The same writer further states that

"In the midst of all the vicissitudes which affect the solar system, the length of the major axes and the mean motions of the planets remain permanently independent of secular changes. They are so connected by Kepler's law, of the squares of the periodic times being proportional to the cubes of the mean distances of the planets from the sun, that one cannot vary without affecting the other. And it is proved that any variations which do take place are transient, and depend only on the relative positions of the bodies."†

This truth was previously borne ample testimony to by Professor Playfair, who with his usual elegance of language says—

"La Grange found, by a method peculiar to himself, and independent of any approximation, that the inequality produced by the mutual action of the planets must, in effect, be all periodical: that amidst all the changes which arise from their mutual action, two things remain perpetually the same, viz., the length of the greater axis of the ellipse which the planet describes, and its periodical time round the sun, or, which is the same thing, the mean distance of each planet from the sun and its mean motion remain constant. The plane of the orbit varies, the species of the ellipse and its eccentricity change; but never, by any means whatever, the greater axis of the ellipse, or the time of the entire revolution of the planet.

* Connexion of the Sciences, p. 408. † Ibid, p. 25.

"The discovery of this great principle, which we may consider as the bulwark that secures the stability of our system, and excludes all access to confusion and disorder, must render the name of La Grange for ever memorable in science, and ever revered by those who delight in the contemplation of whatever is excellent and sublime."*

A recent writer on Astronomy, in a work of some celebrity, says—

"I have already shown how the permanence of the orbit of each planet depends upon the perfect balance of two forces or tendencies, viz., the attractive power of the sun, and that tendency to fly from the centre which follows from the motion of bodies being naturally in straight lines, and whose energy depends in each case upon the rapidity of the body's motion. If the power of either of these balanced forces be diminished, it is clear that the authority of the other will prevail. Relax gravity, therefore, and the planet will recede from the sun, and its orbit will widen until a balance is restored. In the same manner, diminish the rapidity of the body's motion, and as the centrifugal force will be diminished by the same act, gravity will prevail, so that the body's orbit will be contracted or drawn in."†

When we have to deal with the exact sciences, and to bring forward evidences from their resources, the matter is very soon concluded; and, therefore, these three quotations equally confirm, and completely so, the first and last assumptions with which we commenced; because, before the laws which are mentioned in them could have been established, the relative mass of the earth, with respect to the sun and other bodies of our system, must have been determined with unerring precision; and, consequently, whatever that was, at the most remote period to which astronomical calculations have any reference, it must be the same at this moment; for, as the earth's mean distance from the sun is invariable, and the law of gravitation exacts a proportional increase or diminution of the mass, should the distance be enlarged or reduced, it follows as an axiom, *that as the distance has remained the*

* Review of Laplace, Mecanique Celeste, Playfair's Works, vol. iv. p. 289.

† Nichol's Architecture of the Heavens, p. 152.

same, the mass or weight must also have remained without change.

The next point to be disposed of, is, to prevent any subterfuge being sought in the belief that the secondary strata owe their origin to the comminution or disintegration of pre-existing rocks. The fundamental assumption in our argument, namely, the non-rotation of the earth during the period of the deposition of the stratified masses, is so inseparably connected with that of its being then a sphere of level surface, bounded by a circumfluent ocean, that the possibility of disintegration from previously existing rocky mountains is so incompatible with these that they must either stand or fall together. The change in the *position* of the primary and stratified masses will be explained in its proper place; but in the meantime, we beg that the horizontality of the whole earth during that epoch, may be allowed; and that it be considered sufficient explanation for the absence of disintegration; otherwise, this argument, as far as regards those who withhold this concession, must be brought to a sudden conclusion. Although this may, perhaps, be considered an extreme request by those who are accustomed to witness the primary rocks forming the highest points in almost all mountain ranges, and the secondary ones tilted up, and hanging on their shoulders, yet, when it is considered that it has been adopted as a geological axiom, *that these rocks have been moved through a certain space into their present positions*, we may as fairly consider the intervening space to have been from *horizontality* as from any intermediate inclination; and the more so, as we think we can prove their elevation from a *perfect level;* although we should shrink from the task, if a less static position were imperatively demanded as that of their original starting point.

This brings us to examine into the truth of the only remaining unproved postulate, namely, the existence *underneath* the secondary strata of a boundary line of impenetrable rocks, forming a continuous shell or crust, from *within* which the stratified masses could not possibly have come; and here, before proceeding with any proof, we would, to use the words of Dr. M'Culloch, say—

"It is our object to trace the disposition of the rocky surface of the globe, from the most distant or early point at which the marks of change are perceptible, and to pursue its changes down to the present day. Beyond that distant point it is possible that there may have been other changes; but of these we can find no evidence. A curtain is here drawn to separate the visible world from that which is, to us, as if it had never existed. That this system had a beginning, we are certain; where that may lie, we know not; but for us it is placed beyond that era at which we can no longer trace the marks of a change of order, of the destruction and renovation of its form. It is from this point that a theory of the earth must commence; it is from this also that the present enquiry begins."*

We have even a higher authority for laying this restriction upon our enquiries. The inspired historian himself in his narrative takes up the Creation as the light found it; and from that eventful period only enters into particulars. We assume the Earth to have been without inequalities of form, and bearing upon its rocky level surface a shoreless circumfluent ocean. He narrates that "the Earth was without form and void, and the spirit of God moved on the face of the waters;" while, availing ourselves of what he was made the chosen instrument to reveal, carrying it back, as it were, by the differential method, we apply it and endeavour to fathom the dark and atmosphereless abyss of waters; and thence to spread out before our readers "the wonders of Jehovah's workings of old, which were from the beginning."

Admitting the deposition of the stratified masses from a fluid holding them in suspension and combination, which is not attempted to be denied, then it follows as a matter of course, *that there must have been an under surface of rocks, of some* DESCRIPTION OR OTHER, *which formed the ground-work or base on which the universal menstruum was sustained, while those strata were being deposited from it.*

This general view of the case will be strengthened when we consider that, it is contrary to the laws of matter to suppose, that the original water could have been the matrix of all the

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* Geology, vol. i. p. 462.

rocky materials constituting the solid nucleus of the earth. This would involve the double absurdity of supposing that the containing water increased as the solid nucleus increased, and experienced a corresponding augmentation of earthy sediment in proportion to the increasing demand for deposition. But, as we entertain little fear of such tenets as these being brought forward and sustained, while, on the other hand, the fact of "the strata having been deposited tranquilly in a horizontal position from water holding them in combination"* is never for a moment doubted, we are shut up to the conclusion that, at whatever geological period it may have occurred, there assuredly was, at one time, a solid surface around and all over our earth impervious to water, on which the primeval ocean rested, while from it were being deposited those successive layers of different kinds which constitute the whole of the secondary and part of the tertiary strata; while the animal and vegetable remains found interwoven in these† prove beyond the possibility of a doubt, that the water, however different from the seas of the present day, was capable of sustaining the creatures and plants to which those exuviæ belonged.

The existence of such a universal base is fully admitted by geologists, if we may judge from the tenor of their writings on the subject.‡ Indeed, so much so, that in another part of this work, we have come to the general conclusion, "That the granitic, trappean, and serpentinous classes of rocks, with their immediate associates, form the nucleii of all mountain ranges; that there is a strong analogy between granite, trap, and porphyry; and that their common origin must be sought for in nearly the same source, and from the same cause."§ A few illustrations bearing on these conclusions may be satisfactory before we close this part of our subject.

"Assuming," says Professor Buckland, "that fire and water have been the two great agents employed in reducing the surface of the globe to its actual condition, we see in the repeated operations of

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* 13th and 14th Theorems. † Theorems 16 and 19. ‡ Theorem 21.
§ Theorems 25, 26, and 27.

these agents, causes adequate to the production of those irregular elevations and depressions of the fundamental rocks of the granitic series, which are delineated in the lower region of our system, as forming the base of the entire superstructure of stratified rocks."*

Mr. Lyell states that

"If we investigate a large portion of a continent which contains within it a lofty mountain range, we rarely fail to discover another class, very distinct from either of these alluded to, and which we can neither assimilate to deposits such as are now accumulated in lakes or seas, nor to those generated by ordinary volcanic action. The class alluded to consists of granite, granitic schist, roofing slate, and many other rocks, of a much more compact and crystalline texture than the sedimentary and volcanic divisions before-mentioned. In the unstratified portion of these crystalline rocks, as in the granite, for example, no organic fossil remains have ever been discovered. . . . . .

"These remarkable formations have been called *primitive*, from being supposed to constitute the most ancient mineral productions known to us, and from a notion that they originated before the earth was inhabited by living beings, and while yet the planet was in a nascent state. Their high relative antiquity is indisputable; for, in the oldest sedimentary strata, containing organic remains, we often meet with rounded pebbles of the older crystalline rocks, which must, therefore, have been consolidated before the derivative strata were formed out of their ruins. They rise up from beneath the rocks of mechanical origin, entering into the structure of lofty mountains, so as to constitute, at the same time, the lowest and most elevated portions of the crust of the globe.† . . . . .

"It would be easy," continues the same writer, "to multiply examples to prove that the granitic and trap rocks pass into each other, and are merely different forms which the same elements have assumed, according to the different circumstances under which they have consolidated from a state of fusion. What we have said respecting the mode of explaining the different textures of the central and external parts of the Vesuvian dykes may enable the reader, in some measure, to comprehend how such differences may originate."‡

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* Bridgewater Treatise, vol. ii. p. 3.

† Principles of Geology, vol. iii. pp. 10—13.

‡ Ibid, vol. iii. p. 36.

"It is," says Dr. M'Culloch, "in the deeper regions of the globe, therefore, in those where we have found the origin of granite, that we must seek that of trap. These substances are essentially of the same nature, but they have been produced at distant periods of time. . . . . . It must thus be apparent that whatever differences may exist between trap and granite, whether in their relations to the strata, or their mineral characters, they are strikingly analogous in almost every essential general circumstance, and that the former may, in a certain sense, be considered as a recent granite; as the granite of a newer strata. . . . . .

"I am unable to perceive that anything is wanting to prove the identity of origin in trap and granite. It is little likely, at least, that geology will often furnish us with evidence of a more decided nature. Nor is it an indispensable requisite to this argument to produce numerous examples; since there are innumerable cases in science, among which this seems one, where one or two facts are as decisive as a hundred."*

"Notwithstanding its inferiority in position," continues the same author, "we must not grant, as asserted, that granite constitutes the mass of the globe, or is the lowest rock in existence. Of its interior we know nothing; but its weight is sufficient to prove that it is not formed of granite. . . . . . Some unstratified matter, solid or fluid, does, doubtless, lie beneath the stratified surface of the earth; but while conjectures are fruitless, it might, if solid, be basalt, as well as granite.

"Though treating of it first in order, it is plain that it is not so viewed here; while I need not re-discuss the relations of the stratified to the unstratified rocks. It is sufficient that granite disturbs the former, transmits veins through them, and affects their mineral characters; while the strata do not follow it in that regular order in which they succeed each other; but are variously and confusedly placed with regard to it, so that a single mass may touch all the members of one series—a property not possessed by any stratum. This is posteriority, but it is a posteriority only where the fact of intrusion is thus proved. Rocks have been deposited on it, as I shall immediately show; and in examining the revolutions of the earth, I have rendered it probable that there has been granite, or an analogous substance, prior to all strata, and the original source of the whole."†

* Geology, by Dr. M'Culloch, vol. i. p. 148, et seq.

† Ibid, vol. ii. pp. 87, 88.

Professor Phillips asserts

"*Inferiorly* the primary strata rest on unstratified, generally granitic rocks, so situated as to cut off all possibility of observation at greater depths. This granite floor—this universal crystalline basis to all the stratified rocks—appears, in many instances, to have undergone fusion since the deposition of the strata upon it. . . . . . It is enough for our present purpose to recognize the general truth of the stratified rocks, which are the products of water, resting universally on unstratified crystalline rocks, which, through whatever previous conditions their particles may have passed, have assumed their present characters from the agency of heat. Igneous rocks then rest below all the aqueous deposits."*

As we have already proved the last postulate, namely, that the earth was re-weighed after deposition, and found to be precisely the same as before, we shall consider that, with the copious extracts just given, we have closed the case in favour of the point so important to be established, namely, *that the materials which compose the strata of the secondary and part of the tertiary formations, were at one time contained in the water which surrounded the globe during its period of non-rotation;* and having thus prepared the mind, by freeing it from all bias to the contrary opinion, we shall be the better able to fix upon some admitted order of superposition, from the oldest stratified formation up to the magnesian limestone; as it is indispensably necessary to adopt and to follow out some one geological classification.

"To propose," observes Sir Henry de la Beche, "in the present state of geological science, any classification of rocks which should pretend to more than temporary utility, would be to assume a more intimate acquaintance with the earth's crust than we possess. Our knowledge of this structure is far from extensive, and principally confined to portions of Europe. Still, however, a mass of information has gradually been collected, particularly as respects this quarter of the world, tending to contain general and important conclusions, among which the principal are—that rocks may be

* Treatise on Geology, pp. 69, 70.

divided into two great classes, the stratified and the unstratified; that of the former some contain organic remains, and others do not; and that the non-fossiliferous stratified rocks, as a mass, occupy an inferior place to the fossiliferous strata, also taken as a mass. The next important conclusion is, that among the stratified fossiliferous rocks, there is a certain order of superposition, apparently marked by peculiar general accumulations of organic remains, though the mineralogical character varies materially. . . . . .

"Classifications of rock should be convenient, suited to the state of science, and as free as possible from a leading theory. The usual divisions of primary, transition, secondary, and tertiary, may, perhaps, be convenient, but they certainly cannot lay claim to either equality with the state of science, or freedom from theory."*

As it is intended, amidst the prevailing diversity of nomenclatures and classifications, to adopt that of Sir. H. de la Beche, we opportunately annex his table of comparative classification, to assist in leading us through the difficulties which will assuredly present themselves.†

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* Geology, by Sir H. T. de la Beche, pp. 32, 33.

† Manual of Geology, pp. 38, 39. See also the very comprehensive Table, No. 2, given by Mr. Lyell, in his work, vol iii. pp. 389—393.

CLASSIFICATION OF ROCKS IN A DESCENDING SERIES.

STRATIFIED ROCKS.			IMPROVED WERNERIAN.	CONYBEARE.	OMALIUS D'HALLOY, 1830.		BRONGNIART, 1829.	
SUPERIOR STRATIFIED, OR FOSSILIFEROUS.	1. Modern Group......	Detritus of various kinds produced by causes now in action; coral islands, travertino, &c.	Alluvion..................	....	....		Alluvial and Lysian rocks...	Jovian period.
	2. Erratic Block Group	Transported boulders and blocks; gravels on hills and plains, apparently produced by greater forces than those now in action.	.... Diluvium: Ancient Alluvion.	.... Superior Order.	.... Tertiary rocks.	Secondary.	Clysmian rocks.	
	3. Supercretaceous Group..............	Various deposits above the chalk, such as in England, the Crag, Isle of Wight beds, London and plastic clays. In France, the freshwater and marine rocks of Paris, &c.	Tertiary..................	....	....			
	4. Cretaceous Group..	1. Chalk. 2. Upper green sand. 3. Gault. 4. Lower green sand. To which may be added for convenience, 1. Weald clay. 2. Hastings sands. 3. Purbeck beds.	Secondary.	Supermedial Order.	Ammonean rocks.		Izemian rocks.	Saturnian period.
	5. Oolitic Group	The rocks usually known as the oolite formation, including the lias.						
	6. Red Sandstone Group..............	1. Variegated or red marl. 2. Muschelkalk. 3. Red sandstone. 4. Zechstein. 5. Red conglomerate.						
	7. Carboniferous Group..............	1. Coal measures. 2. Carboniferous limestone. 3. Old red sandstone.	....	Medial Order.	....		Hemilysian rocks.	
	8. Grauwacke Group	Grauwacke, thick-bedded, and schistose, sometimes red; grauwacke limestones; grauwacke clay slates, &c.	Transition.	Submedial Order.	Hemilysian rocks.	Primordial.		
	9. Lowest Fossiliferous Group	Various slates, frequently mixed with stratified compounds, resembling those of the unstratified rocks.	....	....	....			
INFERIOR STRATIFIED, OR NON-FOSSILIFEROUS.	No determinate order of superposition ...	Various schistose rocks, and many crystalline stratified compounds, such as gneiss, protogine, &c.	Primitive, or Primary.	Inferior Order.	....		Agalysian rocks.	
UNSTRATIFIED ROCKS.	Volcanic, Trappean, Serpentinous, and Granitic rocks	Ancient and modern lava, trachyte, basalt, greenstone, corneans, augite and hornblende porphyries, serpentine, diallage rock, sienite, quartziferous porphyry, granite, &c.	Arranged among the stratified rocks according to the order in which they are supposed to occur.	The same as the improved Wernerian.	Pyroidal and Agalysian rocks.		Modern volcanic rocks classed as pyrogenous rocks; igneous rocks of an older date as Typhonian.	

"The greater part of our continents," says Mr. Lyell, "are evidently composed of subaqueous deposits; and in the manner of their arrangement we discover many characters precisely similar to what has been described; but the different groups of strata are, for the most part, on a greater scale, both in regard to depth and area, than in any observable in the new formations of lakes, deltas, or estuaries. We find, for example, beds of limestone several hundred feet in thickness, containing embedded corals and shells, stretching from one country to another, yet always giving place, at length, to a distinct set of strata, which either rise up from under it like the rocks before alluded to as forming the borders of a lake, or cover and conceal it. In other places, we find beds of pebbles and sand, or of clay of great thickness. The different formations composed of these materials usually contain some peculiar organic remains; as for example, certain species of shells and corals, or certain plants. . . . .

"All the subaqueous strata which we before alluded to as overlying the primary, were at first called *secondary;* and when they had been found divisable into different groups, characterized by certain organic remains and mineral peculiarities, the relative position of these groups became a matter of high interest. It was soon found that the order of succession was never inverted, although the different formations were not co-extensively distributed; so that if there be four different formations, as *a*, *b*, *c*, *d*, which in certain localities, may be seen in vertical superposition, the uppermost or nearest of them, *a*, will in other places be in contact with *c*, or with the lowest of the whole series, *d*, all the intermediate formations being absent."*

"The great bulk of the accessible surface of the solid earth," says Dr. M'Culloch, "is composed of stratified rocks, which, under different modes of distribution, form not only the low plains, but the elevated mountains; being brought into view by their irregularities of position, and by that denudation which so often laid them bare, and has generated the lower materials which, in other parts, conceal them from immediate examination. . . . . .

"The term stratum, or bed, carries its own definition with it; its extent, according to the prolongation of its great opposing planes, being generally far greater than its thickness. A repetition of such beds forms a series of strata; and the term stratification implies the mode of their deposition, to whatever cause that may be attributed. . . . . The term stratification, therefore, implies a cause, as well as

* Principles of Geology, vol. iii. pp. 9—15.

a mode of form and disposition; and that cause is assumed, or proved, to consist in a deposition from water, of materials that have been suspended and dissolved in it."*

This brings us to the point where we shall require to adduce some of the innumerable proofs which exist in favour of the *thirteenth* Theorem, "*That wherever any considerable portion of the earth's surface has been examined by geologists, it has invariably afforded proofs of having been at one time submerged in the water of the ocean.*"

"A very little attention," says Professor Playfair, in his Illustrations of the Huttonian Theory, "to the phenomena of the mineral kingdom, is sufficient to convince us, that the condition of the earth's surface has not been the same at all times as at present. When we observe the impressions of plants in the heart of the hardest rocks; when we discover trees converted into flint, and entire beds of limestone or of marble composed of shells and corals; we see the same individual in two states—the most widely different from one another; and in the latter instance, have a clear proof, that the present land was once deeply immersed under the waters of the ocean."†

"The lowest and most level parts of the earth," M. Cuvier asserts in his Theory, "when penetrated to a very great depth, exhibit nothing but horizontal strata composed of various substances, and containing almost all of them innumerable marine productions. Similar strata, with the same kind of productions, compose the hills even to a great height. Sometimes the shells are so numerous as to constitute the entire body of the stratum. They are almost everywhere in such a perfect state of preservation that even the smallest of them retain their most delicate parts, their sharpest ridges, and their finest and most tender processes.

"They are found in elevations far above the level of every part of the ocean, and in places to which the sea could not be conveyed by any existing cause. They are not only enclosed in loose sand, but are often encrusted and penetrated on all sides by the hardest stones. Every part of the earth, every hemisphere, every continent, every island of any size, exhibits the same phenomenon. We are therefore forcibly led to believe, not only that the sea has at one period

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* Geology, by Dr. M'Culloch, vol. i. pp. 61, 67.

† Playfair's Works, vol. i. p. 19.

or another covered all our plains, but that it must have remained there for a long time, and in a state of tranquillity; which circumstance was necessary for the formation of deposits so extensive, so thick, in part so solid, and containing exuviæ so perfectly preserved."*

"Geologists," Sir John Herschel states, "now no longer bewilder their imaginations with wild theories of the formation of the globe from chaos, or its passage through a series of hypothetical transformations, but rather aim at a careful and accurate examination of the records of its former state, which they find indelibly impressed on the great features of its actual surface, and to the evidence of former life and habitation which organized remains imbedded and preserved in its strata indisputably afford.

"Records of this kind are neither few nor vague, and though the obsoleteness of their language, when we endeavour to interpret it too minutely, may, and no doubt often does, lead to misapprehension, still its general meaning is, on the whole, unequivocal and satisfactory. Such records teach us, in terms too plain to be misunderstood, that the whole, or nearly the whole, of our present lands and continents were formerly at the bottom of the sea, where they remained deposits of materials from the wearing and degradation of other lands not now existing, and furnished receptacles for the remains of marine animals and plants inhabiting the ocean above them, as well as for similar spoils of the land washed down into its bosom."†

"Calcareous rocks," says Mr. Lyell, "containing the same class of organic remains as our transition and mountain limestones, extend over a great part of the central and northern parts of Europe, are found in the lake districts of North America, and even appear to occur in great abundance as far as the border of the Arctic sea. The organic remains of these rocks consist principally of marine shells, corals, and the teeth and bones of fish; and their nature, as well as the continuity of the calcareous beds of homogenous mineral composition, concur to prove, that the whole series was formed in a deep and expansive ocean, in the midst of which, however, there were many isles." . . . . .

Again—

"A glance at the best geological maps now constructed of various

* Cuvier's Theory of the Earth, by Professor Jamieson, pp. 7, 8.

† Natural Philosophy, in Cab. Cyc. pp. 282, 283.

countries in the northern hemisphere, whether in North America or Europe, will satisfy the enquirer, that the greater part of the present land has been raised from the deep, either between the period of the deposition of the chalk and that of the strata termed tertiary, or at subsequent periods, during which various tertiary groups were formed in succession. For, as the secondary rocks, from the lias to the chalk inclusive, are, with a few unimportant exceptions, marine, it follows that every district now occupied by them has been converted into land since they originated."*

Evidences so unanimous and so conclusive leave not a doubt, that "wherever the earth's surface has been examined to any extent, it affords undeniable proofs of having been formed at the bottom of the ocean." The importance of this demonstration, however, cannot be fully appreciated until it has been shown, that there was *only one general elevation* of the strata; and, consequently, that the stratified masses which afford such perfect evidence of their submarine origin, *must have been so situated at one and the same time;* while their having been simultaneously covered by the ocean, proves alike that the earth must, of necessity, have been a sphere without rotatory motion; for no other form could fulfil all the conditions required, when the comparative shallowness of the ocean is taken into account;† and the impossibility of this ever covering the earth's surface after the first revolution around its axis had taken place, and occasioned those great inequalities, which, at present, distinguish its geographical outlines. Without dwelling longer, however, on this great truth for the

* Principles of Geology, vol. i. pp. 146, 155.

† Sir H. T. de la Beche considers the ocean to be only two miles in mean depth, and his evidence on this point is so apposite that we cannot avoid giving it:—"The depth of the ocean has been variously estimated at between two and three miles. The mean height of the dry land above the ocean level does not exceed two miles. Therefore, assuming two miles for the depth of the ocean, the waters occupying three-fourths of the Earth's surface, the present dry land might be distributed over the bottom of the ocean in such a manner that the surface of the Earth would present a mass of waters—an important possibility, for with it at command, every variety of the superficial distribution of land and water may be imagined; and consequently every variety of organic life, each suited to the various situations and climates under which it would be placed."—Manual of Geology, pp. 2, 3.

present, but resting satisfied with having shown that wherever any considerable area of the earth's surface has been accessible to geological examination, it affords the clearest possible evidence of having been formed beneath the water of the ocean, we shall next proceed to give some equally conclusive quotations in support of the first part of the *fourteenth* Theorem, in which it is asserted *that the stratified rocks afford sufficient evidence of having been formed in succession, horizontally and tranquilly, by deposition from water.*

"It is well known," says Dr. Hutton's accomplished illustrator, "that on removing the loose material which forms the immediate surface of the earth, we come to the solid rock, of which a great proportion is found to be regularly disposed in strata, or beds of determinate thickness, inclined at different angles to the horizon; but separated from one another by equidistant superfices, that often maintain their parallelism to a great extent. These strata bear such evident marks of being deposited by water, that they are universally acknowledged to have their origin at the bottom of the sea; and it is also admitted that the materials of which they consist were then either soft, or in such a state of comminution and separation as rendered them capable of arrangement by the action of the water in which they were immersed. Thus far most of the theories of the earth agree: but from this point they begin to diverge, and each to assume a character and direction peculiar to itself. . . . . .

" . . . . . The materials of the strata are disposed, as we have already seen, loose and unconnected, at the bottom of the sea; that is, even on the most moderate estimation, at the depth of several miles under its surface. . . . . .

"Now, it is certain that many of the strata have been moved angularly; because that, in their original position, they must have been all nearly horizontal. Loose materials, such as sand and gravel, subsiding at the bottom of the sea and having their interstices filled with water, possess a kind of fluidity; they are disposed to yield on the side opposite to that where the pressure is greatest, and are, therefore, in some degree, subject to the laws of hydrostatics. On this account they will arrange themselves in horizontal layers; and the vibrations of the incumbent fluid, by impressing a slight motion, backward and forward, on the materials of these layers, will very much assist the accuracy of their level. . . . . .

"Now, rocks having their layers exactly parallel, are very com-

mon, and prove their original horizontality to have been more precise than we could venture to conclude from analogy alone. In beds of sandstone, for instance, nothing is more frequent than to see the thin layers of sand separated from one another by layers still finer of coaly or micaceous matter, that are almost exactly parallel, and continue so to a great extent without any sensible deviation.

" These planes can have acquired their parallelism only in consequence of the property of water just stated, by which it renders the surfaces of the layers which it deposits parallel to its own surface, and therefore parallel to one another. Though such strata, therefore, may not now be horizontal, they must have been so originally, otherwise it is impossible to discover any cause for their parallelism, or any rule by which it can have been produced."*

In the following exposition, we find the stratified formation of the Earth's crust and its universal submersion deduced from the presence of organic remains, by Mr. Whitehurst:—

" The remains of marine animals embedded in the solid substance of stone in all parts of the known world are so extremely numerous that it is needless to add any more instances relative to their origin; let us, therefore, proceed to a recapitulation of the facts, in order to draw some general conclusions concerning them.

" 1. Fossil bodies, resembling both in substance and shape the shells of living fish, are found imbedded upon the highest mountains, in valleys, and deep recesses of the earth, remote from the sea.

" 2. They are found retaining the native testaceous matter, colour, and figure of marine shells; insomuch as not to have been distinguished from the shells of living fish.

" 3. Fossil shells are also found variously impregnated with stony or metallic matter, and even changed into the substance of the stone in which they are imbedded.

" 4. They are found in the solid substance of the limestone *strata*, dispersed throughout their whole extent and thickness; some of these being 150 or 180 feet thick. They are also involved in *strata* of chalk and clay.

" 5. The bivalve species are found with both their shells entire, as those of living fish; each bed consisting of one particular

* Playfair's Huttonian Theory, pp. 4, 44—46.

species, namely oysters, cockles, muscles, &c., collected together as the same species are actually assembled together in the sea.

"6. But, on the contrary, when beds of fossil shells are composed of fragments, or separate bivalves, they consist of a variety of species confusedly blended together, in like manner as the fragments of sea-shells are thrown together by the fluctuation of the ocean.

"7. Fossil bones and teeth, resembling those of fish, are also found retaining the perfect colour, figure, and polish of recent teeth; but though the number of such fossil bodies are very considerable, yet the shells of fish are infinitely more numerous; and I have not discovered a single instance of the *former* being imbedded with the latter in the limestone *strata* in Derbyshire, or elsewhere; but constantly with a variety of adventitious matter near the surface of the earth.

"8. And we may add to the above, that the remains of terrestrial animals are seldom or never found intermixed with marine relicts in the limestone *strata;* neither are those of the sea ever found, or but rarely, in the argillaceous *strata* containing the impressions of vegetables.

"Such are the general phenomena attending the above fossil bodies; whence the following inferences seem to arise:—

"First. Their great analogy, in figure, colour, and consistence, to the shells, bones, and teeth of living fish, together with a gradual change in their component parts, from a testaceous, to a stony, or metallic substance, evidently shows that all such fossil bodies were originally productions of the sea.

"Secondly. Their being found in all parts of the world, even imbedded in the highest mountains, vallies, and deep recesses of the earth, remote from the sea, evidently shows that the sea prevailed universally over the earth, and consequently, that these marine animals were created prior to the terrestrial animals, agreeable to the Scriptural account of the Creation.

"Thirdly. And, since they are found at various depths in the earth, even to that of several thousand feet, and in different states of decay, and variously impregnated with stony or metallic matter, and even changed to the substance of the stone in which they are imbedded, it evidently appears that the *strata* were originally in a state of fluidity, and that they were thus entombed and deprived of life in successive periods of time.

"Fourthly. The beds of fossil shells, which consist of one species only, and although not natives of the climate where now found, but

of very distant regions of the earth, evidently show that they were generated, and have lived and died *in the very beds where found*, and could not have been removed from a distance by a flood or floods of water with so much order as to form beds consisting of only one species ; and, therefore, ALL SUCH BEDS MUST HAVE BEEN ORIGINALLY THE BOTTOM OF THE OCEAN.

"Such are the inferences deduced from the preceding facts ; which tend to corroborate the several results arising from the former parts of this enquiry into the original state and formation of the earth, namely, that the earth was originally a fluid, chaotic mass, totally unfit for animal or vegetable life. That it was progressively formed into an habitable world. That marine animals were created prior to the terrestrial animals. That they were entombed in the bowels of the earth in successive periods of time, and before dry land appeared."*

"For more than two centuries," says Mr. Lyell, when reasoning on the *unphilosophical assumption of the discordance of the ancient and existing causes of change*, "the shelly strata of the sub-appenine hills afforded matter of speculation to the early geologists of Italy, and few of them had any suspicion that similar deposits were then forming in the neighbouring sea. . . . . . Some imagined that the strata, so rich in organic remains, instead of being due to secondary agents, had been so created in the beginning of things by the fiat of the Almighty ; and others ascribed the imbedded fossil bodies to some plastic power which resided in the earth in the early ages of the world. At length Donati explored the bed of the Adriatic, and found the closest resemblance between the new deposits there forming, and those which constituted hills above a thousand feet high in various parts of the peninsula. He ascertained that certain genera of living testacea were grouped together at the bottom of the sea in precisely the same manner as were their fossil analogies in the strata of the hills, and that some species were common in the recent and fossil world. Beds of shells, moreover, in the Adriatic, were becoming incrusted with calcareous rock, and others were recently inclosed in deposits of sand and clay, precisely as fossil shells were found in the hills. . . . . .

" . . . . . It must always have been evident to unbiassed

* Enquiry into the Formation of the Earth, by John Whitehurst, F.R.S., London, 1786, pp. 55—59.

minds, that successive strata, containing in regular order of superposition, distinct beds of shells and corals, arranged in families as they grow at the bottom of the sea, could only have been formed by slow and insensible degrees in the lapse of ages; yet, until organic remains were minutely examined and specifically determined, it was rarely possible to prove that the series of deposits met with in one country was not formed simultaneously with that found in another. But we are now able to determine, in numerous instances, the relative dates of sedimentary rocks in distant regions, and to show by their organic remains that they were not of contemporary origin, but formed in succession. We often find that where an interruption in the consecutive formations in one district is indicated by a sudden transition from one assemblage of fossil species to another, the chasm is filled up, in some other district, by other important groups of strata."*

While we refer to the table given of the classification of rocks, by Sir H. T. de la Beche, by which the great portion of the stratified, and, consequently, the deposited ones will at once be recognized, we consider it opportune to subjoin the following detached quotation from his Manual, in which, it will be observed, he assumes the stratified masses to be established as deposits, and treats of them as such by inference:—

"Having premised this much," he says, "respecting the geographical distribution of the cretaceous group, we will take a slight sketch of the variations in its mineralogical character. Throughout the British Islands, a large part of France, many parts of Germany, in Poland, Sweden, and in various parts of Russia, there would appear to have been certain causes in operation, at a given period, which produced nearly, or very nearly, the same effects.

"The variation in the lower portion of the deposit seems merely to consist in the absence or presence of a greater or less abundance of clays or sands, substances which we may consider as produced by the destruction of previously existing land, and as deposited from waters which held such detritus in mechanical suspension. The unequal deposit of the two kinds of matter in different situations would be in accordance with such a supposition. But when we

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* Principles of Geology, vol. i. pp. 96—99.

turn to the higher part of the group into which the lower portion graduates, the theory of mere transport appears opposed to the phenomena observed, which seem rather to have been produced by deposit from a chemical solution of carbonate of lime and silex covering a considerable area. . . . . .

" When we view the oolitic group as a whole, such as it occurs over a considerable portion of Western Europe, we cannot but be struck with the general uniformity of its structure. The three great argillo-calcareous deposits alternate with as many that are calcareous or arenaceous, but principally the former. When we attempt to apply the operation of such causes as those we daily witness in explanation of this uniformity, we seem to involve ourselves in innumerable difficulties, though to explain certain minor appearances they may be useful. . . . . . In a general view of this deposit it would seem better to consider it in connexion with the succeeding group. As joined with it, it appears the upper part of one great mass which has been deposited in various inequalities of surface, the superior portion frequently overlapping the inferior part, so that it rests directly on the older rocks," and so forth.

" The red sandstone group succeeds in the descending order. . . . The rocks composing this group occur in the following descending order: 1. Variegated marls; 2. Muschel chalk; 3. Red or Variegated Sandstones; 4. Zechstein; and 5. Red Conglomerate, or Todtliegendes. . . . . .

" If we now abstract our attention from the divisions, and regard the group as a mass, it would seem to constitute the base of a great system of rocks, which when not deranged by local accidents has filled numerous hollows and inequalities of land over considerable parts of Europe. . . . . . During their deposit, great and remarkable changes were effected in animal, and, perhaps, vegetable life; and it seems somewhat necessary to admit that considerable differences in the relative levels of sea and land were produced at various times, causing changes in the character of the inhabitants of the sea, from variations of pressure and other circumstances, while no small difference might be effected from the filling up and rise of the bottom. . . . . .

" The coal measures are composed of various beds of sandstone, shale, and coal, irregularly interstratified, and, in some countries, intermixed. They abound in vegetable remains, and the coal itself is now, by very general consent, referred to a vegetable origin, being considered the accumulation of an immense mass of plants.

. . . . By general consent the coal is considered as resulting from the distribution of a body of vegetable remains over areas of greater or less extent, upon a previously disposed surface of sand, argillaceous silt or mud, but principally the latter, now compressed into shale.

"After the distribution of the vegetables, other sands, silt, or mud, were accumulated upon them. . . . . . Great length of time would be requisite for this accumulation, because the phenomena observed would lead us to consider the transporting power, though variable, to have been generally moderate; moreover, a very considerable growth of vegetables requiring time would be necessary at distinct intervals; for coal beds now only six or ten feet thick, must, before pressure was exerted upon them, have occupied a much greater depth. . . . . .

"It has been observed that the old red sandstone of some countries graduates into grauwacke, whence it may be inferred that the causes, whatever they may have been, which produced the latter deposit, were not violently interrupted in such situations, but that they were gradually modified. . . . . .

"If the size of transported substances be considered as the necessary evidence of rapid currents of water, the grauwacke rocks taken as a mass have been slowly deposited; for, though evidences of cross currents are sufficiently abundant in the various directions of the laminæ, and in the mode in which arenaceous and slaty beds are associated with each other, the substances are generally fine grained, rarely passing into conglomerates. . . . . . There is, however, a general appearance in the mass of the grauwacke which would lead us rather to consider a great portion of it of slow deposition. . . . . .

"The grauwacke group occurs in Norway, Sweden, and Russia. It forms a portion of Southern Scotland, whence it ranges, with breaks formed by newer deposits or the sea, down Western England into Normandy and Brittany. It appears abundantly in Ireland. A large mass of it is exposed in the district constituting the Ardennes, the Eifel, the Westerwauld, and the Taurus. Another mass constitutes a large portion of the Hartz mountains, while smaller patches emerge in other parts of Germany, on the north of Magdeburg, and other places. In all these situations there is, notwithstanding small variations, a general and prevailing mineralogical character, which points to a common mode of formation over a considerable area.

"From all the accounts, also, that have been presented to us by Dr. Bigsby and other American geologists, we have every reason to consider that a deposit closely agreeing in relative antiquity, and in its general mineralogical and zoological characters, exists extensively in North America: so that there is evidence, also, to show that some general causes were in operation over a large portion of the northern hemisphere, and that the result was the production of a thick and extensive deposit, enveloping animals of similar organic structure over a considerable surface. . . . . .

"We have now arrived," says the same intelligent geologist, "at that early condition of our planet when, as far as our knowledge extends, neither animal nor vegetable life existed on its surface. . . .

"The inferior stratified rocks are of various compositions, sometimes so passing into each other that it is almost impossible to affix definite names to the different mixtures.

"It would be tedious to enumerate the various situations where these inferior stratified rocks may be found; it will suffice to state, that there is scarcely any large extent of country where, from some accident or other, they are not exposed on the surface. They abound in Norway, Sweden, and Northern Russia; they are common in the north of Scotland, whence they stretch over into Ireland. In the Alps and some other mountains, they occupy the central lines of elevation, as if brought to light by the movements which have thrown up the different chains. They abound in the Brazils, and occur extensively in the United States. Our navigators have shown that they are sufficiently common in the various remote parts of North America visited by them. They are found extensively in the great range of Himalaya. Ceylon is in a great measure composed of them; and they do not appear to be scarce in various other parts of Asia.

"In Africa, also, we know that they are not wanting, though but so small a part of that continent has been yet explored with scientific views. Hence we may consider that whatever may be the nature of the deposits on which we stand, such strata exist beneath us, unless in cases where masses of igneous rocks have, by protrusion, forced them asunder, and left no stratified substances intermediate between the surface and the interior of the globe."*

A geologist, who has written more recently, expresses his

* Manual of Geology, by Sir H. T. de la Beche.

opinion, as far as the Old Red Sandstone group is concerned, in the following graphic manner, with which we shall close this part of the evidence:—

"The geologists of the school of Werner," says he, "used to illustrate what we may term the anatomy of the Earth, as seen through the spectacles of their system, by an onion and its coats. They represented the globe as a central nucleus, encircled by concentric coverings, each covering constituting a geological formation. The onion, through the introduction of a better school, has become obsolete as an illustration, but to restore it again, though for another purpose, we have merely to cut it through the middle, and turn downwards the plane formed by the knife. It then represents, with its coats, two such hills as we describe—hills such as Ben Nevis, ere the granite had perforated the gneiss, or the porphyry broken through the granite."

After pointing out in another passage how unsafe it is to calculate the depth of deposits by the altitude of hills, or to estimate the correctness of the calculations made in one district by those which may have been made in some other widely separated locality, he states—

"So enormous is the depth of the deposit (the red sandstone) in Caithness, that it has been deemed by very superior geologists to represent three entire formations:—the Old Red System, by its unfossiliferous, arenaceous, and conglomerate beds; the Carboniferous system, by its dark-coloured middle schists, abounding in bitumen and ichthyolites; and the New Red Sandstone, by its mottled marls and mouldering sandstones that overlie the whole;" and which unitedly, "in some localities attain a depth fully equal to the elevation of Mount Etna over the level of the sea."*

* Old Red Sandstone, by Miller, Edinburgh, pp. 60, 61, and 52.

SECTION IV.

DEPOSITION OF THE STRATA DURING THE NON-ROTATORY PERIOD.

CHAPTER IX.

Further inferences respecting the existence of the elements of the strata in the primitive ocean; and of the crystalline base on which they universally repose. Attendant circumstances of the Earth in perfect accordance with the work of deposition then going on. Character and component elements of the lower stratified, or non-fossiliferous rocks, given with the design of showing that their elements existed in the primitive menstruum. Endeavours to describe the process by which these elements were abstracted from the water with which they were thus combined. The immediate influence of the luni-solar current exemplified by the theory of the tides. Geological construction of the non-fossiliferous rocks—confusedly crystalline. Their specific gravity given, and the influence of attraction in their formation. Aqueous crystallization, and the predominating influence which it exercised at this early stage of the creation. Capacity of water for becoming chemically impregnated with mineral elements shown and corroborated by the waters of Carlsbad and other mineral springs. Chemical affinity; its universality and influence. Brief summary in conclusion of this, as a preparation for succeeding Chapters.

The copious and concurring extracts which we have given in the preceding chapter sufficiently prove the deposition from water of the stratified rocks which now constitute a great portion of the solid crust of the earth. They also bear testimony to the fact, that those successive layers rest upon a base of unstratified material, from *within* which they could not possibly have come.

The sphericity of the earth's surface, which has been premised, precludes it from being supposed that the strata owe their origin to the disintegration of pre-existing rocks; while

it has been shown by a combination of fundamental astronomical laws, that no increase of the weight or gravity of the globe took place since its creation; and that the only addition made to it was the principle of organic life in the inferior animal and vegetable existences which were then brought into being; but as this living principle added not one iota to the gravity of our sphere, we have, as the result of our well-sustained premises, a right to conclude *that the elements of the strata which formed part of the weight of the Earth at the beginning, were contained in the circumfluent ocean; and were deposited from it.* But we must here be allowed to observe, that it was not alone by the separation of the mineral material parts, by *deposition*, that the primeval water became the pellucid seas of the present day; the gaseous elements of the atmosphere were, by combination with the principle of light, when formed, made to *ascend* from the water, and, by their abstraction, also to purify and leave the ocean what we now find it. If it be admitted, therefore, that the ponderous earthy masses were, on the one hand, taken by precipitation from the primitive water, and that the volatilized gaseous elements were made to rise out of them, on the other—all having originally been contained *in* the water when "the Earth was without form and void, and darkness was upon the face of the deep"—surely, without departing in the slightest degree from philosophical reasoning, or going too far, it may be demanded, for argument's sake, that they may be considered for a short while to be restored to them; while the non-existence of the atmosphere will render this concession, as far as regards the gaseous elements, all the more easily granted. And it having been shown, by the writings of geologists, that the strata now rest upon a base of unstratified rocks, we may safely consider, that the water which held the elements of the strata in its grasp rested, before these were deposited, *on that on which the deposited matter now reposes;* while to complete the proper conception of the condition of our planet at the remote period to which we allude, we have only to imagine it, thus geologically constituted, to be without rotatory motion, but circulating with the same velocity and in the identical orbit through darkened space, wherein it now travels around the illumined sun.

If there be anything which, more than another, we desire to avoid in conducting this work, it is that of assuming any unnecessary or unfounded supposition as the base line of our subsequent conclusions. *We assume nothing but what we feel assured we can prove by well-sustained evidence in the sequel.* Our senses prove to us undoubtedly that the Earth at present rotates, is illumined by the sun, and is beautifully diversified by hill and dale, and by the greater inequalities of continental ridges and oceanic hollows. Yet, in asking our readers to imagine, that the world which they now inhabit, with all these advantages, would have presented to the vision—if eyes there had been to behold it—a shoreless abyss of dark and atmosphereless water, devoid of rotatory motion, and deprived of the soul-cheering rays of the sun, we do no more than truth dictates to us: *for this was its actual condition for many ages.* It is thus first of all presented to our notice in the Sacred Volume, wherein it is announced that "the Earth was without form and void; darkness was upon the face of the deep, and the spirit of God moved upon the face of the waters."

If this revealed description be believed in, and its non-rotation conceded for a short time, we feel confident we can prove that it did *not* rotate for a long but indefinite period, and that it was then in the dark and atmosphereless condition to which allusion has so frequently been made.

Before entering upon any investigation as to the *manner* in which the deposition of the strata took place, it will contribute to the certainty of our convictions were we made aware, that the attendant conditions of the Earth were in accordance with that perfect wisdom which characterizes the operations of Omnipotence. To be assured of this we purpose to enquire, whether the spherical form of the globe, surrounded by an illimitable ocean of equal depth, was not better adapted for promoting the deposition of earthy matter from a fluid, than the relative distribution of land and water, with unequal depths, and reduced aqueous surface, which at present constitute its geographical features; and whether, under any possible circumstances, and at any period, the sea could have covered the whole sphere.

To do this we shall refer to the *first* Theorem, in which it

is stated, "*That a sphere is that form which contains the greatest volume of all bodies of equal surface.*" This, applied to the case under consideration, assures us, that a sphere is that form capable of containing the greatest possible mass of matter within a given quantity of water, and to permit this last to maintain the greatest possible depth while it circumbounds the contained solid mass. In this state the globe and its aqueous envelope are conceived to have remained during the entire period of non-rotation. By referring to the *eighth* Theorem it will be observed, that the aqueous portion of the earth's present surface is to the terrestrial part as *three* to *one*, or nearly so; i. e. only three-fourths of superfice is now covered by the same water which formerly circumbounded its whole extent; and if, from the *first* Theorem, we take the diameter of the Earth, we shall soon discover what a vast area that is, and how admirably adapted the surface then was for favouring deposition from a fluid holding matter in suspension; while, if we take into account that the most moderate estimate makes the mean depth of the ocean two miles, others considering it between four and five, and that even the highest mountain rises only two miles above the level of the sea—the greater portion of the earth's surface having but a very limited elevation above that level—no doubt will remain as to the possibility, under the premised conditions of the globe, of the water of the ocean having covered the whole surface of a non-rotating sphere; thereby more fitly adapting it for the gradual deposition of the earthy matter contained in the circumfluent water.* Thus we acquire, by every additional step in the investigation, increasing evidences of the infinite wisdom which directed the whole plan of creation, and become more and more strengthened in our confidence in the revelations which God has been pleased to make of His operations, when no eye was present to behold His wonderful doings.

We have next, in the prosecution of this laborious research, to ascertain the nature and component parts of the *stratified rocks* throughout the series which are supposed to have been

* See note at page 319.

thus deposited, and enquire into some of the causes then in operation which contributed to their formation.

The inferior stratified or non-fossiliferous rocks, according to Sir Henry de la Beche, consist of

"1. Clay; 2. Aluminous Slate; 3. Whetstone Slate; 4. Flinty Slate; 5. Chloride Slate; 6. Talcose Slate; 7. Steachiste, Hornblende Slate; 8. Hornblende Rock; 9. Quartz Rock; 10. Serpentine; 11. Diallage Rock; 12. Whitestone; 13. Mica Slate; 14. Gneiss; and 15. Protogine: with respect to which he remarks—

"Although the above are the most remarkable of the inferior stratified rocks, they are far from being the whole of them. The varieties and transitions of one to the other appear endless, and, occurring in no determinate order, set classifications utterly at defiance. . . . . .

"If we consider what minerals have entered most largely into the composition of the whole mass, we find that quartz, felspar, mica, and hornblende are those with which it most abounds, and which impress their characters upon its various portions. Chlorite, talk, and carbonate of lime are certainly not wanting; but if we, as it were, withdraw ourselves from the earth and look down upon such parts of its surface as are geologically known, we find that these latter mineral substances constitute a very small portion of the whole. The inferior stratified rocks, which form the largest part of the exposed surface of our planet, are gneiss and mica slate, and when viewed on the great scale the others are more or less subordinate to them.

"Supposing this view an approximation to the truth, we arrive at another and important conclusion, namely, that the minerals which compose the mass of these stratified rocks are precisely those which constitute the mass of the unstratified rocks—rocks which from the phenomena attending them, are referred to an igneous origin. . . . . We find, still viewing the subject in the mass, that the same elementary substances have produced the same minerals in both, the only difference between them being their general difference of arrangement relatively to each other, so that they should constitute a stratified compound in the one case, and not in the other.

"Viewed on the large scale, the grauwacke series consists of a large stratified mass of arenaceous and slaty rocks intermingled with patches of limestone, which are often continuous for considerable distances. The arenaceous and slate beds, considered generally,

bear evident marks of mechanical origin, but that of the included limestones may be more questionable. The arenaceous rocks occur both in thick and schistose beds; the latter state being frequently owing to the presence of mica disposed in the lines of the laminæ. Their mineralogical character varies materially; and while they sometimes, though rarely, pass into a conglomerate, they very frequently graduate into slates, which become of so fine a texture as to lose the arenaceous character altogether. Roofing slate is not rare among the grauwacke rocks; and if we consider it of mechanical origin, like the mass of the strata among which it is included, we must suppose it to have originated from the deposition of a highly comminuted detritus.

"The coal measures," according to the same geologist, "are composed of various beds of sandstone, shale, and coal, irregularly interstratified, and in some countries intermixed with conglomerates; the whole showing a mechanical origin.

"The old red sandstone is of very variable thickness, sometimes consisting of a few conglomerate beds, while at others it swells out to the depth of several thousand feet. . . . . . . The sandstone possesses different degrees of induration, and is not unfrequently schistose and micaceous. The conglomerates of course vary in their contents, but pieces of quartz are very common."*

Should further and corroborative evidence be required on this essential point, we can, with all confidence, refer our readers to the detailed and elaborate tables which are given by Mr. Lyell in his "Elements of Geology," which although, in some cases, compiled more immediately from the analyses of rocks composing the older formations, may on the whole be taken as exhibiting pretty nearly the constituent principles of the others also:—

"Chemical science," says Dr Ure, "demonstrates that the crust of the earth consists mainly of six substances, Silica, or the matter of rock crystal, Alumina, or pure clay, Iron, Lime, Magnesia, and Potash. Silica, in the crystalline form, is called quartz, and is a large constituent of the primitive mountains, granite, gneiss, and mica slate. . . . The third of the primitive stratified rocks is clay slate or roofing slate. If to these four bodies, namely, quartz, fel-

* Manual of Geology, by Sir H. T. de la Beche.

spar, mica, and clay slate [called simple minerals, because they are of homogenous aspect], we add hornblende and augite, we shall have before us the principal mineral constituents of the primitive shell of the globe. . . . . .

"Thus we see that silica, clay, lime, magnesia, iron oxide, and potash, constitute by far the greater portion of the hard materials of the earth, as far as it has been explored."*

The following table of the Older Stratified Rocks, taken from the same work, will show the components of the same series, viz.:—

			Concomitants.
Class I. Primitive, or Inferior Rocks.			
	Order I.	Gneiss	Granites.
			Hornblende rocks.
			Limestones.
			Quartz rocks.
	,, II.	Mica	As above.
			Gypsum.
	,, III.	Clay slate . . .	Mica slate.
			Talk slate.
			Chlorite slate.
			Gneiss.
			Whet slate.
			Alum slate.
			Dolomite.
			Gypsum.
Class II. Transition, or Submedial Rocks.			
	Order I.	Grauwacke . . .	Conglomerate.
			Clay slate.
			Flinty slate.
			Alum slate.
			Limestone.
			Dolomite, with Encrimites.
Class III. Medial, or Carboniferous Rocks.			
	Order I.	Old Red Sandstone.	

* Geology, pp. 89, 90.

Order II.	Carboniferous or Mountain Limestone.	Concomitants.
,, III.	Millstone Grit, or Shale.	
,, IV.	Coal Measures .	Coal Sandstone. Slaty clay. Bituminous shale. Carbonate of iron coal. Calcareous marl. Alpine limestone.*

During this part of the inquiry we shall only enumerate four of the groups which pertain to the *Secondary* rocks, the others not being immediately connected with this part of our subject. These are—

First. Grauwacke, which consists of fragments of granite, or chlorite schiste, embedded in a cement principally composed of felspar.

Second. Siliceous Sandstone, formed of fine quartz or sand, united by a siliceous cement.

Third. Aluminous Schiste, or Shale, consisting of the decomposed materials of different rocks, cemented by a small quantity of ferruginous or siliceous matter, and often containing the impression of crystals.

Fourth. Ironstone, formed of nearly the same material as the foregoing, but containing a much larger quantity of oxide of iron.†

By which it appears that the component minerals of those four groups of strata, from the non-fossiliferous series up to the shale and old red sandstone of the coal measures (exclusive of calcareous matter), are 1. Quartz; 2. Felspar; 3. Mica; 4. Hornblende; 5. Clay Slate; 6. Chlorite; and 7. Talk—the two last only occasionally. When these are analysed into their component elements, they are respectively found to consist as follows:—

* New System of Geology, pp. 131, 132.

† Chemistry, by Hugo Reid, p. 154, deduced from Sir Humphrey Davy's Agricultural Chemistry.

1. Quartz—Almost entirely of silica, a little alumina, or oxide of iron, and combined with water.
2. Felspar—63 parts silica, 17 alumina, 13 potash, 3 lime, and 1 oxide of iron.‡
3. Mica—which consists of 46 parts silica, 10 alumina, 50 potash, 14 oxide of iron, and 1.50 oxide of manganese.‡
4. Hornblende—Silica 42 parts, alumina 12 parts, 30 oxide of iron, 11 of lime, magnesia 2.25, 1 feruginous manganese, and water.‡
5. Clay Slate—Affords by analysis 49 parts silica, 23 alumina, 11 oxide of iron, and 5 potash.
6. Earthy Chlorite—Consists of 43 parts oxide of iron, 26 silica, 18 alumina, 8 magnesia, and 2 muriate of soda.‡
7. Talk—has 62-100ths silica, 27-100ths magnesia, alumina 1.50, oxide of iron 3.50, and water 6.‡ *

Thus, by continuing our researches, we have reached a point from whence we can clearly discern, that the whole of those vast rocky formations which contribute so essentially to form the surface of the Earth, when traced to their ultimate constituent principles, are found to be composed of a few simple elements, scarcely exceeding twelve in number; and that they might, perhaps, be found to owe their origin to a still smaller number of undecomposable substances, had we the power, or chemistry had the skill, to analyse still more minutely the objects of its own discovery.

This point, then, at which we have arrived, may under present circumstances be considered, for all practical purposes, an ultimate one. And we shall next endeavour to acquire some conception—imperfect we fear it will be—of the means whereby those elements were separated from the primeval ocean which held them in suspension and combination, and by which they were transformed into those successive layers or strata, which, when the continents arose from their recumbent position by centrifugal impetus, assumed their destined places

* Theorem 103. Chemistry, by Hugo Reid. And Chemical Dictionary, by Dr. Ure.

Those thus distinguished (‡) are confirmed, or nearly so, by Mr. Lyell's Tables.

as the chief supporters of the primary nucleii of the mountain masses.

We must not, however, attempt to conceal the fact, that we have reached an extremely difficult part of our labours; the more so as we are quite incapable of attempting, in anything like a detailed form, an exposition of the manner in which those stupendous works were conducted in the great laboratory of nature. Indeed, as the task in this way would prove altogether hopeless and unavailing, we must restrict ourselves to the proofs which show, that those works *were actually performed;* while we allude merely to the manner in which we consider them to have been effected. While we take this occasion to refer to the *ninety-seventh* Theorem, especially the latter clause, expressing at the same time our entire concurrence in its announcement, "*that there are no operations now taking place in the sea which bear the slightest analogy to those productions of mineral substances in strata which took place formerly on our globe.*"

Should further confirmation be required of this assumption, we beg to refer to those authorities on which the Theorem has been founded, explaining, however, that the analogy spoken of has reference more to the vastness and extent of the ancient deposits than to the mere deposition of strata, as this is perceived to be taking place, on a reduced scale, under the present economy.

Thus, without wasting time and attention in the unsatisfying and fruitless attempt to penetrate into periods too remote in the history of the world's creation; or endeavouring to conceive its rudimentary elements, before they were in that condition in which it has pleased the Creator to introduce them to our knowledge in the sublime and comprehensive announcements of Genesis, wherein He represents himself as beholding His own Creation, as it advanced, step by step, until it reached that state in which He could say that "*He saw every thing that he had made, and behold it was very good;*" and remembering also that He has asked us through another inspired writer, "Where wast thou when I laid the foundations of the earth? Declare, if thou hast understanding. Who hath laid the measures thereof, if thou knowest? or who hath stretched the line upon it?

Whereupon are the foundations thereof fastened? or who laid the corner stone thereof, when the morning stars sang together and all the sons of God shouted for joy?" We repeat that, without attempting to trench on those hidden grounds which are beyond the limits of human comprehension, but submissively and joyfully taking up the song of praise at the point where those higher intelligencies may be said to have passed it on to us; and making an energetic and unbiassed use of the faculties of investigation with which it has pleased Providence to endow us, let us turn our attention to enquire into these works, which, even in His estimation, appeared "very good," whose creation caused those exalted beings "to shout for joy," and which, in the plenitude of goodness, are spread out as a field on which to exercise the powers of mind conferred upon us, and which are, we trust, to occasion within us also similar sentiments of delight and adoration, when the understanding shall have become convinced, and we are enabled to behold them in the same light in which they looked upon them—in the clear light of heaven!

Now, it is by such considerations as these, that the mind—debarred from wasting its powers in endeavouring to comprehend incomprehensible things—can best apply its unimpaired energies to the work which lies before it. We therefore trust that in such a frame of spirit, we may be enabled to imagine a shoreless mass of dark, tremulous water [whose purified remains are the seas of the present day], flowing in a slow, secular, unvarying, and uninterrupted course round a non-rotating sphere, and charged with the elements of countless stratified rocks, while it also held the gaseous constituents of the present outstretched firmament in combination with the mineral ingredients; and doing so, let us endeavour to determine the probable consequences.

Having so frequently alluded to a slow, secular flow of the primitive water round the circumbounded sphere ere it had rotatory motion, we are bound to exemplify how such a state of matters could then have existed; and, happily, we are provided by the amiable writer on the *Connexion of the Sciences*, with an illustration of the present tides, which by analogy will render this quite evident to all.

"It is proved," says that accomplished writer, "by daily experience, as well as by strict mathematical reasoning, that if a number of waves or oscillations be excited in a fluid by different forces, each pursues its course, and has its effect independently of the rest. Now, in the tides there are three kinds of oscillations, depending on different causes, and producing their effects independently of each other, which may therefore be estimated separately.

"The oscillations of the first kind, which are very small, are independent of the rotation of the earth; and as they depend upon the motion of the disturbing body in its orbit, they are of long periods. The second kind of oscillations depends upon the rotation of the earth, therefore their period is nearly a day. The oscillations of the third kind vary with an angle equal to twice the angular rotation of the earth, and consequently happen twice in twenty-four hours. These are the semi-diurnal tides so remarkable on our coasts. They are occasioned by the combined action of the sun and moon; but as the effect of each is independent of each other, they may be considered separately."

As the first only of these bears upon our present subject, we shall enter more particularly into it.

"The particles of water," says the same writer, "under the moon are more attracted than the centre of gravity of the earth, in the inverse ratio of the square of the distances.* Hence they have a tendency to leave the earth, but are retained by their gravitation, which is diminished by this tendency. On the contrary, the moon attracts the centre of the earth more powerfully than she attracts the particles of water in the hemisphere opposite to her; so that the earth has a tendency to leave the waters, but is retained by gravitation, which is again diminished by this tendency. Thus the waters immediately under the moon are drawn from the earth at the same time that the earth is drawn from those which are diametrically opposite to her; in both instances producing an elevation of the ocean of nearly the same height above the surface of equilibrium; for the diminution of the gravitation of the particles in each position is much the same, on account of the distance of the moon being great in comparison of

* It will of course be understood, that although the sun and moon were not illumined at the period we treat of, yet the consequences resulting from the gravity of the unillumined bodies were the same as at present.—AUTHOR.

the radius of the earth. Were the earth entirely covered by the sea, the water thus attracted by the moon would assume the form of an oblong spheroid, whose greater axis would point towards the moon, since the columns of water under the moon and in the direction immediately opposite to her, are rendered lighter in consequence of the diminution of their gravitation; and in order to preserve the equilibrium, the axis 90° distant would be shortened. The elevation, on account of the smaller space in which it is confined, is twice as great as the depression, because the contents of the spheroid always remain the same.

"If the waters were capable of assuming the form of equilibrium instantaneously, the form of the spheroid, its summit, would always point to the moon, notwithstanding the earth's rotation. But, on account of their resistance, the rapid motion produced in them by rotation, prevents them from assuming, at every instant, the form which the equilibrium of the forces acting upon them requires. Hence, on account of the inertia of the waters, if the tides be considered relatively to the whole earth and open sea, there is a meridian about 30° eastward of the moon where it is always high water both in the hemisphere where the moon is, and that which is opposite. On the west side of this circle the tide is flowing, on the east it is ebbing, and on every part of the meridian at 90° distant it is low water. This great wave, which follows all the motions of the moon as far as the rotation of the earth will permit, is modified by the action of the sun, the effects of whose attraction are in every respect like those produced by the moon, though greatly less in degree; consequently a similar wave, but much smaller, raised by the sun, tends to follow his motions, which at times combines with the lunar wave, and at others opposes it, according to the relative positions of the two luminaries; but as the lunar wave is only modified a little by the solar, the tides must necessarily happen twice a day, since the rotation of the earth brings the same point twice under the meridian of the moon in that time, once under the superior, and once under the inferior meridian. . . . . .

"Besides these remarkable variations, there are others arising from the declination or angular distance of the sun and moon from the plane of the equator, which have great influence on the ebb and flow of the waters. The sun and moon are continually making the circuit of the heavens at different distances from the plane of the equator, on account of the obliquity of the ecliptic, and the inclination of the lunar orbit. The moon takes about twenty-nine days

and a half to vary through all her declinations, which sometimes extend $28\frac{3}{4}$ degrees on each side of the equator, while the sun requires nearly three hundred and sixty-five days and a quarter to accomplish his motion from tropic to tropic through about $23\frac{1}{2}$ degrees; so that their combined motion causes great irregularities, and, at times, their attractive forces counteract each other's effects to a certain extent; but, on an average, the mean monthly range of the moon's declination is nearly the same as the annual range of the declination of the sun; consequently, the highest tides take place within the tropics, and the lowest towards the poles."*

To comprehend the nature of the luni-solar current which must have periodically traversed the whole extent of the primitive ocean, there requires only to be added to this beautiful and perspicuous illustration of the theory of the present tides, the conditions peculiar to our planet previously to the formation of the light, namely, its non-diurnal rotation round its axis; the universality of the ocean; and the circulation of our planet in space round the unillumined sun, accompanied by its opaque satellite, the moon; in which state, the force and effects of gravity being the same then as now, it is evident that a current flowing from east to west would be constantly circulating round the globe, whose oscillations would vary in degree, and keep pace with the circulation of the moon in its orbit, and, consequently, would take place twice within the lunar month, and produce the greatest disturbance of the aqueous balance, and its velocity upon those parts, now the equator, where it had to perform the greatest circuit, while it diminished to nothing where the poles of revolution now are.

The only other peculiarity is, that the non-rotating earth presented the same side towards the sun as it revolved in annual circle round its unillumined centre, and, as a consequence thereof, according to the foregoing theory of the tides, there would be two points on the earth's surface having luni-solar tidal ridges; the one immediately under the sun and moon, the other 180° from it, or diametrically opposite; while it must

* On the Connexion of the Sciences, pp. 105—110. If more information be required on this point, please refer to Herschel's Astronomy, chap. xi.

not be lost sight of, that in consequence of there being no rotation on the earth, the attractive influence of the moon and sun would exercise full power, unrestricted by the counter-action of rotation in the water, as shown to be the case at present by the extracts just given; and, consequently, the primeval water was capable of assuming the form of equilibrium, and spontaneously to occasion all the results flowing therefrom.

In order not to distract the attention, we shall abstain, for the present, entering into any disquisition to show that there was likewise a continual current from upwards downwards throughout the whole extent of the primitive water, as we shall have occasion presently to make this manifest in its proper place. We merely announce it here as another fact capable of being proved.

Perhaps the most convincing method of procedure will now be to show, by extracts from the writings of geologists, even though we should repeat some recently given, the particulars, structure, and mineralogical character of the lower stratified or non-fossiliferous formations; and, having effected this, afterwards to determine whether, according to this theory, the requisite elements and means existed in the primitive water for their formation.

Sir Henry de la Beche, when treating of the non-fossiliferous rocks, says—

"The inferior stratified rocks are of various compositions, sometimes so passing into each other that it is almost impossible to affix definite names to the different mixtures. The strata rarely present a simple mineral substance constituting a large tract of country, without the admixture of other substances, unless we consider clay slate as such."

After enumerating the several descriptions of rocks forming this comprehensive group, he goes on to say—

"Although the above are the most remarkable of the inferior stratified rocks, they are far from being the whole of them. The varieties and transitions of one to the other appear endless, and, occurring in no determinate order, set classification utterly at defiance.

"All this apparent confusion, though it embarrasses arrangements, may be precisely the circumstances which may lead to some knowledge of the causes which have produced the lowest stratified rocks. . . . . . The causes, whatever they may have been which produced this variety in the substances, were secondary, and there was some general cause upon which the formation of the whole depended.

"If we consider what minerals have entered most largely into the composition of the whole mass, we find that quartz, felspar, mica, and hornblende are those with which it most abounds; . . . . . . chloride, talk, and carbonate of lime are certainly not wanting; . . . . but of those parts which are geologically known, these latter mineral substances constitute a very small portion of the whole. The inferior stratified rocks which form the largest part of the exposed surface of our planet are gneiss and mica slate, and, when viewed on the great scale, the others are more or less subordinate to them."*

"We have now," says Mr. Lyell, "to examine those strata to which the name of *metamorphic* has been assigned. . . . . . These rocks, when in their most characteristic or normal state, are wholly devoid of organic remains, and contain no distinct fragments of other rocks. . . . . . They sometimes extend over areas of vast dimensions, occupying, for example, nearly the whole of Norway and Sweden, where, as in Brazil, they appear alike in the lower and higher grounds. . . . . . Many attempts have been made to trace a general order of superposition in the members of this family. . . . . But although such an order may prevail throughout limited districts, it is by no means universal, nor even general throughout the globe. . . . . . The following may be enumerated as the principal members of the metamorphic class: gneiss, mica-schist, hornblende, schist, clay-slate, chlorite-schist, hypogene or metamorphic limestone, and certain kinds of quartz-rock, or quartzite."†

According to Professor Phillips,

"Inferiorly the primary strata rest on unstratified, generally granitic rocks, so situated as to cut off all possibility of observation at greater depths. . . . . . The rocks included in the division of primary strata may be referred to three principal types: siliceous, argillaceous, and calcareous. The most important siliceous rocks

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* Manual of Geology.

† Lyell's Elements, vol. ii. pp. 379, 380.

are gneiss, mica slate, quartz rock, chlorite slate, hornblende slate, and sandstones, which latter occur in the upper part.

"The argillaceous rocks are less varied: clay slate, grauwacke slate, grauwacke, and various shales.

"The calcareous portions are somewhat remarkable amongst limestones for their generally crystalline character; even the fossiliferous rocks have much of this feature, and all the older beds are really crystallized. . . . . . Induration or consolidation to a high degree is a general property of these strata. There is, in fact, no clay, no sand, no marl, in the whole series."*

These concurring extracts afford sufficient testimony to lead to the conclusion, that the mineralogical structure of the lower stratified or non-fossiliferous rocks is "confusedly crystalline," and that they owe their origin to some common cause of extensive prevalence, during the protracted period of their deposition and formation.

Considering that the rocks of the era alluded to are so irregular as to set classification and arrangement almost at defiance, although their subjection to order has been attempted and persevered in by the most accomplished geologists of the day, the assertion on our part might almost be dispensed with, that neither do we consider ourselves called upon, nor are we warranted to attempt more than a mere surmise as to the causes which may have brought about those results, and occasioned the "confused crystalline" conformation so evidently pourtrayed by the objects of our present investigation. At the same time it should not be overlooked, that in the depositions themselves we are furnished with the best and most irrefragable proofs of the existence, at some period or other, of those mineral ingredients in the primeval water.

There seems to be no doubt left upon the mind as to the fact, *that the primitive circumfluent water was* CHEMICALLY *saturated with mineral elements, which in succession were abstracted from them, by deposition, through the agency of commensurate means*, to which we shall have occasion shortly to

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* Phillips's Geology, pp. 69—71.

make frequent and particular allusion. This truth seems to be admitted by all who have paid any attention to the subject, and, therefore, we shall now dwell only on the fact itself of the *chemical saturation of the original ocean.*

To saturate effectually any mass of water with ingredients soluble in it, the best means which can be adopted is to charge the menstruum throughout with finely comminuted material, in order that the powers of absorption and chemical affinity inherent in the fluid may be equally, generally, and effectually brought into exercise; while those powers are considerably augmented by the simultaneous presence of certain gasses, especially oxygen, which it is known everywhere abounded in the primitive water.

Without presuming determinately to assert that such did occur during the development of the great plan of creation at a period so remote, and while the stony concretions of the earth's surface were so devoid of denotation by organic remains, yet we seem warranted, from a combination of the known effects of the general laws which then prevailed, together with the actual findings of geologists, to suppose, that there might have been a stage, in the earth's geological history, when the means employed to form concentric layers of rock may have been so simple, as to be little less rudimentary than the method alluded to; and that the circumfluent water, in order that it might become thoroughly and generally saturated, *chemically*, with the elements afterwards deposited in a crystalline arrangement of structure, was mechanically surcharged with finely comminuted earthy material.

When we contemplate the peculiar circumstances of our planet at the period during which those deposits are considered to have been made—unknown to rotatory motion, unaffected by external light, and surrounded everywhere by the primeval ocean, "the earth without form and void, darkness on the face of the deep"—we can have no difficulty in perceiving, that the law of *attraction* acting on those particles of inert matter, free to percolate through water, would be wholly unabated by any of those counteracting causes which, under a different condition of the earth, might have impeded their

progress to the bottom of the ocean. Now, the several descriptions of mineral matter which constitute the inferior stratified or non-fossiliferous rocks, are represented by numbers so comparatively high in the scale of specific gravities—for instance, fibrous quartz 3.25, felspar 2.57, hornblende 3.25, mica 2.65, clay slate 2.65, oxide of iron 3.45, chlorite 2.60, and talk 2.77, that we must confess they would be specially amenable to the influence of the force in question, and be more readily precipitated from a fluid holding their surplus quantity in mechanical suspension; while we have only to imagine, what cannot very well be doubted, that aqueous crystallization, for which all the attendant circumstances were admirably adapted, was in full operation at the same time, to be able readily to recognise how, between these two causes, the precipitated rocks of that period would assume "a confusedly crystalline" structure, and be composed of the comparatively ponderous materials to which we have just alluded.

The result of those combined operations on the general plan, besides so far purifying the water, would be to lay a solid base, on which fixed animals and other apulmonic ones of restricted motion were to dwell, and acotyledonous plants were afterwards to grow, both contributing to the perfection of the rocky zone which, for the very purpose, they were made to tenant; while the pre-deposition of so much earthy matter, by means next to mechanical, would save those organized beings—incapable by their conformation of evading it—from being suddenly entombed in a descending mass of earthy matter.

We find a confirmation, to a certain extent, of this opinion, in the idea which Mr. Whitehurst formed, as early as 1786, when "the enquiry" which he was then instituting into the "formation of the Earth," required that he should direct his attention to this incipient part of its history. While we need hardly, after what we have written, point out how widely we dissent from the concluding words of the extract, or from any other which would occasion the erroneous conception that there ever was a stage of the creation when that which existed was less consistent with the laws of materialism than what now prevails, during a stage which we are pleased to

consider more perfect. The elements, then, no doubt were incipient, but they were being created in perfect order, and according to a plan which was devised from all eternity, and executed with unerring wisdom. The following are Mr. Whitehurst's conclusions on the subject in question :—

"It will be readily granted, that if the earth was created, it must have been brought into existence either in a solid, or in a fluid state : if we suppose the former, it must have been dissolved, and this by an universal dissolvent principle : therefore, since no such principle is yet known to exist in nature, it seems much more reasonable to conclude, that the fluidity of the earth was owing to the first assemblage of its component parts, than to any subsequent solution. . . . . .

"The fluidity of the earth manifestly implies that the particles of matter which now compose the strata and all other solid bodies, were not oiginally united, combined, or fixed by cohesion, but were actually in a state of separation, as particles of sugar or salt dissolved and suspended in water.

"It is a truth universally known, that the component parts of the most dense bodies become suspended in whatever menstrua they are dissolved ; as for instance, the particles of gold in *aqua regia*, silver in *aqua fortis*, salts in water, and water in air. Nay, we may likewise add, that the component parts of mercury, in the act of distillation, become suspended in air, notwithstanding the specific gravity of the former is to that of the latter, as 11,000 to 1, nearly. Such, therefore, are the consequences necessarily arising from the infinite divisibility of matter, none being heavier or lighter than another, when thus reduced to their original elementary principles.

"Whence it appears, that when the component parts of the earth were first assembled together, they were in a state of uniform suspension, and seem to have composed one general undivided mass or pulp, of equal consistence and sameness in every part, from its surface to its centre ; and, therefore, constituted that particular state and condition of the earth which the ancients have named *chaos*, and have described as a confused mass or pulp, composed of all the various elementary principles blended together, and *without form and void*. That is to say, the chaos had not yet acquired an oblate spheroidical form, and the component parts thereof were void of that arrangement which constitutes bodies of different denominations ; as *air*, *water*, *stone*, *minerals*, &c., but the whole mass com-

posed of the various elementary principles blended together in one confused heap."*

As already observed, sedimentary accumulation seems to have been only one of the means employed, at that early stage of the Creation, to form the bases of the stratified rocks; their mineralogical character clearly indicating that almost from the beginning, at least as far back as geologists have yet penetrated, aqueous crystallization was an influential and a general agent in the hands of the Omnipotent to produce, in perfect order, the framework of those rocky layers, those confusedly crystalline masses described by M. de la Beche and the other geologists from whose works we have quoted.

When we look upon crystallization from aqueous elements, which it seems to have pleased the Creator to have employed before there should be a dawn, even, of animal or vegetable existence; and when we contrast the beautiful and symmetrical arrangement of the particles, in the many-formed mineral crystals, with the mere juxtaposition of particles in the structure of other inert masses, we cannot avoid being impressed with the belief that *crystallization* fills up a gap, or forms an intermediate link, as it were, in the agency of creation, between mere inert matter, and the organic forms which denote animal and vegetable life. Although neither the reproducing creature nor the propagating plant be there, yet *polarization* is so far endued with those energies of perpetuation, that when the same material elements are placed within its reach and under its control, the same forms and similar symmetrical arrangements of particles invariably follow, so that cube succeeds cube, and rhomboid succeeds rhomboid, as certainly and as persistently as patella does patella, or equisetum equisetum. It is true they are not reproduced the one by the other; nevertheless, from causes much more applicable to the then condition of our planet, owing to its universality, and possibility of being employed, simultaneously, at almost every pin's point throughout the whole extent of the earth's surface, and at the

* Enquiry into the Formation of the Earth, by John Whitehurst, F.R.S. London, 1786.

bottom of its dark and circumfluent ocean, equivalent effects were produced, and the work of the Creator accomplished.

This interesting but comparatively modern branch of science has been made the theme of so many works of late, and been so much brought before the learned, that scarcely anything beyond allusion need be made to the Theorems which have been embodied here. They are numbered *one hundred and eleven*, and *one hundred and twelve*. Neither need we bring forward protracted evidence to establish their contents; yet the following brief notices may prepare the mind for the application which we intend to make of them hereafter:—

"It remains," says Mr. Donovan, "to consider the restoration of cohesion to bodies in which that force had been suspended. . . . . This may have been effected through the intervention of a liquid. If a large quantity of sugar be dissolved in a small quantity of boiling water, and the syrup allowed to grow cold, the attraction of cohesion will begin to take effect between its particles, and, at length, the sugar will once more become a solid.

"But in this case, as in many others, whatever may have been the original state of the sugar, it always, in resuming its solidity, assumes a particular one of great regularity and beauty.

"It was originally opaque; it is now transparent. It was originally a shapeless mass; it is now a prism of six sides, in regularity and lustre scarcely to be surpassed by the products of the lapidary's wheel. A solid of this symmetrical form, and of spontaneous production, is called a *crystal*, and the process by which it is produced is called *crystallization*. . . . . . Many bodies are found naturally in the crystalline state, as various precious stones and minerals."*

"Crystallization is an effect," says Mrs. Somerville, "of molecular attraction, regulated by certain laws, according to which atoms of the same kind of matter unite in regular forms—a fact easily proved by dissolving a piece of alum in pure water.

"The mutual attraction of the particles is destroyed by the water, but, if it be evaporated, they unite, and form in uniting, eight-sided figures, called octahedrons. . . . . . It is quite clear, that the same circumstances which caused the aggregation of a few particles would, if continued, cause the addition of more; and the process

* Chemistry, in Cab. Cyc. pp. 17, 18.

would go on so long as any particles remain free round the primitive nucleus, which would increase in size, but would remain unchanged in form, the figure of the particles being such as to maintain the regularity and smoothness of the surfaces of the solid, and their mutual inclinations. . . . . .

"A variety of substances in crystallizing combine chemically with a certain portion of water which, in a dry state, form an essential part of their crystals; and, according to the experiments of M.M. Haidinger and Mitscherlich, seem in some cases to give the peculiar determination to their constituent molecules.

"These gentlemen have observed that the same substance, crystallizing at different temperatures, unites with different quantities of water, and assumes a corresponding variety of forms. . . . . .

"It must be observed that these experiments give entirely new views with regard to the constitution of solid bodies. We are led from the mobility of fluids to expect great changes in the relative positions of their molecules which must be in perpetual motion, but we were not prepared to find motion to such an extent in the interior of solids. . . . . .

"All these circumstances tend to prove that substances having the same crystalline form must consist of ultimate atoms having the same figure and arranged in the very same order; so that the form of crystals is dependent on their atomic constitution."*

It fortunately happens that those views have been fully corroborated by the discoveries of others, who have closely applied themselves to the experimental part of this branch of science; and not resting satisfied by merely propounding the *rationale* of a crystal's formation, have set about, and actually produced them from the ingredients of which they were known to be composed. We allude more especially to Mr. Cross, M. Bequerel, and Dr. Farraday. The first, who has made electrical phenomena his study for many years, states the circumstance of a voltaic apparatus remaining in constant action for twelve months, and from the influence of this continued electric action, he had produced, not only crystals of lime, but that he had likewise submitted powdered flint to its influences, and found that around the positive pole, crystals

* Connexion of the Sciences, pp. 124—127.

of quartz were formed, but not touching the wire. He subsequently produced crystals of iron pyrites at the negative pole from elements of these crystals ; and has now various crystals of copper, tin, silica, and lime in daily formation. The crystals of aragonite were formed from the water of a cave in Somersetshire, highly charged with the carbonate and sulphate of lime, by submitting this water to the action of a common water-battery (for he used no acid), in nine days' time. He also mentions a very material and curious fact, *that light is detrimental to the progress of crystallization*, and that the action of the battery was greater between the hours of seven and ten in the morning, being at that period, from repeated observations, at its maximum; and at the same hour in the evening at its minimum. Barometrical, thermometrical, and other assumed causes he found to have no effect on this latter circumstance.*

It will be seen by the following extract from Professor Buckland's late work, that he adopts views somewhat similar to those brought to light by Mr. Cross's experiments:—

"The experiments of M. Bequerel," he observes, "on the artificial production of crystallized insoluble compounds of copper, lead, lime, &c., by the slow and long-continued reaction and transportation of the elements of soluble compounds, appear to explain many chemical changes that may have taken place under the influence of feeble electrical currents in the interior of the earth, and more especially in veins. I have been favoured by Professor Wheatstone with the following brief explanation of the experiments here quoted :

"'When two bodies, one of which is liquid, react very feebly on each other, the presence of a third body which is either a conductor of electricity, or in which capillary action supplies the place of conductibility, opens a path to the electricity resulting from the chemical action, and a voltaic current is formed which serves to augment the energy of the chemical action of the two bodies. In ordinary chemical actions, combinations are effected by the direct reaction of bodies on each other, by which all their constituents simultaneously concur to the general effect, but in the mode considered by Bequerel

* Literary Gazette, 27th August, 1836. Further information will likewise be found in Gazette of 15th October, 1836, pp. 667, 668.

the bodies in the nascent state, and excessively feeble forces are employed, by which the molecules are produced, as it were, one by one, and are disposed to assume regular forms, even when they are insoluble, because the character of the molecules cannot occasion any disturbance in their arrangement. By the application of these principles, that is, by the long-continued action of very feeble electrical currents, this author has shown that many crystallized bodies, hitherto found only in nature, may be artificially obtained."*

What has now been gone through will, we think, have sufficiently prepared the mind for reasoning with those truths which have been brought out. To do this effectually, however, we shall have to carry the attention back to a period somewhat earlier in the earth's formation. We must endeavour to realize a time when the water was charged with mineral matter in *mere mechanical suspension.*

In attempting to do this we have particular need of the caution with which we set out, to avoid trenching, in the slightest manner, on the boundary line which prohibits enquiry, and be content with coming to conclusions on matters within the grasp of the comprehension; in short, to avoid the quagmires of geology, and adhere as closely as possible to its firm ground, although it may have been little trodden, and may pertain more to clear deductions than to actual research.

The way we feel inclined to look upon this part of our subject, and the view, perhaps, which is the least exposed to error, is this: We find, at the present moment, an immense mass of water contained within, and resting upon, a framework of solid rocks. When those rocks are examined into, they reveal to us, as well by their mineralogical as their geological structure, that they have been very differently formed. Those which are nearest to us, or the more recent, bear evident marks of having been carried about by water, and having been, as it were, thrown down suddenly and violently from them; like sedimentary deposits from water in agitation and motion.† Below these, again, are more extended forma-

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* Bridgewater Treatise, vol. i. pp. 552, 553.

† Theorem 32nd, and its proofs.

tions exhibiting as undeniable symptoms of having been deposited slowly, tranquilly, and persistently from water holding their ingredients so firmly in suspension as to part with them particle by particle, deliberately, and, as it were, by compulsion, by means of its animal and vegetable inhabitants.* Going downward still, we find more compact rocks, whose stratified texture shows that they also have been the product of water, but water acted upon and seemingly drained of its material by one universal agent, which, by the infinitude of sparkling, symmetrical crystals which it has formed, evinces how general has been its operations, and how effectual its work.†

All these have evidently been held in suspension by water; but held in such a manner, that had it not been for those successive agencies which were employed to disturb its chemical equilibrium, for wise and beneficent purposes, it might have continued holding them until now in suspension, or as long as it pleased the Creator. When we penetrate still lower, we next encounter rocks whose structure is heterogenous and confused, manifesting both the influence of crystallization, and simple aggregation of particles, apparently by mere juxta-position; and last of all we come to a species of rock, or rather a diversified series of rocks, of vast and general extent, in which all traces of depositon from water are wholly lost. They are clearly unstratified, or without symptoms of having been formed in layers or beds; while the crystallization they exhibit seems to have owed its origin more to heat than to the slow molecular aggregation of an aqueous origin.‡

When we make an effort, and take all these great and successive formations of mineral matter into our mind at once, and estimate them with relation to the quantity of the water in our present seas, whose average depth is considered to be only two or three miles, we must, of necessity, draw the inference, that while the water positively did contain a great part of these rocks, it could *not* contain the whole of them. It is physically impossible. There is not capacity in the ocean

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* 14th Theorem, and proofs. † 23rd and 18th Theorems, and evidences.

‡ 23rd, 24th, and 25th Theorems, and proofs; likewise Table at page 315.

to have contained all the rocks of the world. Now, when we reflect on all this, we must come to the conclusion *that there was an epoch in the geological history of the world, when, in obedience to the laws impressed upon them, some parts of its earthy crust were condensed into a solid form, and left the turbid aqueous portion, charged with similar material, resting on the base thus formed beneath it.*

Supposing such to have been the case, and, indeed, all the facts connected with this period seem to imply that it was so, the water which, by its lighter specific gravity, assumed the exterior position would, we apprehend, have become charged with mineral ingredients *beyond what it could keep in suspension*; what it has parted with confirms this conclusion. We have only, therefore, to infer that, conformably to the laws which govern matter, it would first part with its surplus, according to the specific gravity of the ingredients, which, likewise, seems to have been the case, as we have shown, when endeavouring to explain the mineralogical structure of the lower rocks. What is chiefly required, at present, is to direct the attention to the undeniable fact, fully evidenced by the discoveries of geologists, that the primeval water was at one period actually charged abundantly with mineral ingredients; that *from it has been deposited, at some time or other, and during the succession of ages, the greater part of what are termed the stratified rocks.* We are not solicitous about determining the precise period *when* those deposits took place, nor, at present, *how* they took place, but merely to be allowed the admission which, we apprehend, cannot consistently be withheld, that such actually did take place.

Supposing therefore such to have been the case, and presuming that water then possessed the same absorbing powers which it does now, and from having been surcharged with gaseous elements its powers of absorption would even be much greater; it follows, obviously, that the primitive water must have become *chemically* saturated with the mineral ingredients which were thus percolating through it. It cannot be expected that we are to bring forward evidence so undeniable as that which is afforded by analysis, or by examination, to prove

that the original ocean *was so impregnated,* but we can offer facts evidenced by what have been extracted from it, layer after layer, thin scaly sheets of stone having been deposited from it, and, in addition, we can adduce the corroborative analogical evidence that water *now,* even when exposed to the evaporating influences of the atmosphere and of sunlight, is occasionally met with holding in chemical combination ingredients almost similar to those which we suppose the dark and atmosphereless primitive ocean to have contained. Without fatiguing the reader with diversified analyses, we shall, on account of their being so well known, give that of the water of Carlsbad, in Bohemia.

According to the analysis made by M. Berzellius, and referred to by Dr. Ure, the mineral matter found in these springs consists of

Sulphate of soda	2.58714.
Carbonate of soda	1.25200.
Muriate of soda	1.04895.
Carbonate of lime	0.31219.
Fluate of lime	0.00331.
Phosphate of lime	0.00019.
Carbonate of strontia	0.00097.
Carbonate of magnesia	0.18221.
Phosphate of alumina	0.00034.
Carbonate of iron	0.00424.
Carbonate of manganese	a trace.
Silica	0.07504.
	5.46656."*

We find a corroboration, to a certain extent, of this last evidence, in a note by M. de la Beche, when treating of the "variations in the mineralogical character of the cretaceous group." The passage and note run thus:

" When we turn to the higher part of the group, into which the lower portion graduates, the theory of mere transport appears

* Ann. de Chim. et de Phys. XXI. p. 248. See also Tables in Murray's Chemistry, vol. ii. pp. 741—743.

opposed to the phenomena observed, which seem rather to have been produced by deposition from a chemical solution of carbonate of lime and silex, covering a considerable area."

Then follows the note :—

"If we regard present appearances, we find that silex is held in solution by thermal waters, which also, as in the case of those of St. Michael in the Azores, may contain carbonate of lime. No springs or set of springs that we can imagine, are likely to have produced this great deposit of chalk so uniform over a large surface. But although springs, in our acceptation of the term, could scarcely have caused the effects required, we may, perhaps, look to a greater exertion of the power which now produces thermal water for a possible explanation of the observed phenomena."*

This quotation and the foregoing analysis (besides many similar ones which may be seen by referring to the synoptical table of mineral waters in the same work), will sufficiently show what diversified ingredients water can, at the same time, hold in chemical combination.

When it is considered that the condition of the primitive ocean, charged with gaseous elements, without an atmosphere to act as an absorbent, and without the influence of the sun's rays to aid in withdrawing, or in volatilizing those aeriform elements, was much better adapted for holding extraneous earthy matter in solution, we shall not be surprised to find, by inference drawn from the nature of the deposits, that the following ingredients were, at the same time, suspended in the primitive ocean, viz: silica, alumina, lime, magnesia, baryte, strontia, glucina, zirconia, potash, soda, ammonia, oxides of iron, manganese, tin, copper, and other metals, iodine, carbonic, fluoric, sulphuric, and nitric acid, with free oxygen, and other gaseous elements, which will be enumerated in the sequel.†

In continuation, we shall enquire into the chemical laws which, under the appellation of general affinities, influence

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* Manual of Geology, 2nd edition, pp. 264, 265.

† Theorems 96, 97, 99, and 100.

their procedure, when brought into contact by a solvent or carrier, such as the circumfluent water of the primitive ocean.

"There must be some power or influence," states Mr. Hugo Reid, "operating to draw bodies into such intimate union with each other, and to express their power, we use the term *chemical* attraction. We know not how this power operates, and know not its nature; we can only judge of it from its effects, and we see that it is the nature of these substances to be united in this way when they are brought together; also we see that a great number of other substances have a disposition to unite in a similar manner; hence we infer that there is some peculiar influence acting between substances which disposes them to unite with each other, and as they appear to be attracted or drawn towards each other, it is called *attraction*, and receives the epithet "*chemical*," to distinguish it from other kinds of attraction.

"By combination (chemical union), two different bodies unite and form a third, differing very much from either. It is chemical attraction which causes them to combine when brought together, and thus this agent is the cause of the differences which we find in bodies. Were there no such agent as chemical attraction, there would be only about 54 different kinds of substances: the simple bodies, and of these several are very rare; but chemical attraction makes these unite with each other, and these compounds unite with the simple substances, and with each other, so that we may say there is almost no end to the number of different bodies brought into existence. It draws towards each other the particles of *different* kinds of matter and binds them together, causes them when they are brought into contact to enter into new arrangements and combinations, and thus gives rise to the variety in the objects around us, and to the varied phenomena of chemistry."*

Mr. Donovan, writing on the subject of chemical affinity, thus expresses himself—

"The natural forces, gravitation and cohesion, belong, in their full development, more to mechanics than to chemistry. . . . . . But there are other forces in nature to be considered which fall more exclusively within our province; and which, so far as this planet

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* Chemistry, by Hugo Reid, p. 8.

is concerned, act a part equal in importance and interest to any other."

After exemplifying the different effects which result from the immersion, in mercury, of a rod of iron, and of a rod of gold, and showing that part of the mercury has become intimately combined with the gold on the surface of the latter, he proceeds to say—

"This, then, is to be acknowledged as a different exhibition of the attractive force that pervades all matter; it is distinguished by the name of *chemical attraction*, or simply by the term *affinity*—a more convenient but less expressive term; and it differs from all known forces in its agency. . . . . .

"This kind of attraction acts upon matter in all states, whether solid, liquid, or gaseous.

"When a piece of sugar is thrown into water, it sinks to the bottom; yet, after a time, by the taste of the water it will be proved, contrarily to the laws of gravity, to have ascended towards the top and spread to all other parts; it must, therefore, have been gradually attracted. The same would happen with salt, alum, and various other articles between which and the water, affinity is known to exist. . . . . . And so, likewise, with two fluids, between which affinity subsists. Thus: spirit of wine is lighter than water, and if poured cautiously over water, it will float; but, after a length of time, it will be found to have descended to the bottom, and to be equally diffused through all parts, in consequence of affinity. But if oil be poured on water, it will remain there during any period, for it is lighter than water, and is not attracted by any strong affinity to that liquid. . . . . .

"This attraction does not act at any distance which can be perceived; its existence is only discoverable by its effects, but its consequences are very striking, and the changes it produces are of such a nature as cannot be overlooked. . . . . . By melting two metals into *combination* extraordinary changes are produced. . . . . What the nature of the change may be that is thus produced on the two metals cannot be explained, but it is certain that, in the mixed mass, the contiguity of a particle of one kind of metal produces a very decided change on the properties of the adjoining particle of the other, and a property is produced by their union which neither particle apparently possesses. . . . . .

"The change of properties which takes place when chemical attraction acts is not confined to metals, but is a general result in every case where different bodies are brought into this state of combination, or chemical union.

"Frequently we find that the properties of each body are totally changed; and that substances, from being energetic and violent in their nature, become inert and harmless, and *vice versa*. . . . . . . One of the chief differences," he goes on to say, "between *chemical* and *cohesive* attraction is, that the former takes place only between the particles of different kinds of matter, whereas the latter occurs between the particles of the same kind. . . . . .

"Another great difference between cohesion and affinity is, that mechanical force is of no avail, as in the case of mere cohesion, where affinity has taken place; for, let the compound be ever so completely divided, each particle of it will consist of all the ingredients which entered into the composition of the original compound, and in the same proportions; and no mechanical contrivance can separate them. . . . . .

"We have now to enquire," says he, "whether or not affinity is a force of very extensive operation in nature; whether it acts in the case of certain kinds of bodies only, or is a general property of matter. The facts known seem to warrant the inference that there are no two bodies between which an affinity does not subsist, ... although there may be antagonistic forces which prevent their combination. . . . . .

"Most of the great changes which are constantly taking place in nature, are instances of decomposition and chemical affinity. It is by decomposition that the solid rock becomes covered with a fertile soil; it is by the same agencies that the soil throws up its verdant clothing; that growing plants are converted into animals by assimilation; that animals at length fall into decay, and return into their original state. In fine, it is by decomposition that the great natural processes of renovation and decay are kept in a state of perpetual circulation."*

In these data we have, seemingly, all that is required to enable us to enter into the investigation of the proceedings of nature in the formation of rocky masses, by the united agency

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* Chemistry, in Cab. Cyc. pp. 20—25.

of simple deposition, of crystallization, of animal and vegetable secretion, and of chemical combination; for we have a universal solvent holding an almost indefinite quantity of the various elementary materials in solution, and itself constituting a carrier to assist in their union; we have the radical principles of electrical phenomena; we know the names and natures of most of the ingredients employed; we are aware there was a constant current in the primeval water flowing round the globe from luni-solar influences; and that there were other currents within the water itself, caused by the unequal degrees of gravity of the aqueous strata; and possessing all these particulars, together with the knowledge we have just acquired of the nature of chemical influence and attraction over the elements of matter held in suspension, which cause them to unite together and form an almost endless variety of other substances, we may, we apprehend, consider ourselves fully prepared to enter on the investigation of what took place during the formation of those stratified masses *whose constitution appears evidently to have been the chief end of the co-existence and operation of all those means, and to have been wrought out during a protracted but indefinite period of non-rotation*, when all the concomitant circumstances were peculiarly favourable for the accomplishment of what was then designed.

SECTION IV.

DEPOSITION OF THE STRATA DURING THE NON-ROTATORY PERIOD.

CHAPTER X.

Position assumed, that the primeval water was chemically saturated with the mineral elements of the strata; and could, therefore, according to the laws of affinity, arrive at a static condition of chemical equilibrium. To produce any change of this state there must have been the intervention of a power beyond materialism, and the employment of an agency exempted from the law of gravitation. Aqueous crystallization apparently the first means made use of to produce that change by the Creator: evidences of this discoverable in the earlier strata. Animal and vegetable vitality next introduced to continue the same effect. Wisdom shown by the sequence of these agencies, and their influence on the progressive work of the creation. The vast extent and depth of the calcareous formations. Beneficence in the design of the relative position which these hold in the order of superposition. The mineral elements—how dissolved and held in combination by the primitive menstruum and their affinities; how they operated in causing deposition when the general equilibrium was disturbed by aqueous crystallization, and by animal and vegetable life. The wise adaptation of these constraining agencies to overcome chemical affinities, and to form substances which otherwise would have been injurious to future life. In conclusion, animal death, and the effects produced by the gaseous exhalations arising from their decomposition.

Before we prosecute our investigations more closely, by endeavouring to discover what was likely to follow from the conditions laid down in the preceding chapter, we would take leave to sum up the evidence, with the design of coming to a perfect understanding upon a point of such essential import. Having made good the position that the primeval water, which circumbounded the rocky nucleus of the earth, was, at one

time, charged with mineral material, which, by some means or other, became separated from its sustaining menstruum, and was slowly and tranquilly deposited at the bottom of the ocean, it follows as a corollary, that those mineral masses were associated with that vast, shoreless, and atmosphereless body of water, *in part by chemical affinity*, and thereby held, to a certain extent, in suspension *by* it.

This must be admitted, if it even should be alleged, that a much greater proportion of the stratified rocks is the product of mechanical deposition, than what even the most liberal construction of geological research will permit; because, while the rocky elements were percolating mechanically through the water, to assume that position at the bottom which their specific gravities occasioned them to do, the ocean, for the reasons which have been assigned, must have become chemically saturated with those very percolating ingredients, as they passed onwards and downwards. This brings us, at last, to the point we so long wished to reach, *that the primitive oceanic water must have been, at one time, chemically charged with mineral elements.*

Now, it is a fact well known and admitted, that water—especially large masses of water—when chemically impregnated with such extraneous substances as it is capable of taking into combination in that state, continues to purge itself, as it were, of every superabundant particle of any one of these ingredients until a *static condition of perfect equilibrium is assumed;* after which, if in vacuo, and *no new element be added or none of the original ones withdrawn*, it will, for aught we know, continue to maintain the same state of chemical equlibrium *ad infinitum*.* This principle is so well known and admitted, that we need scarcely embarrass the general argument by bringing forward evidence to prove it; although it should be borne in mind that we are treating of a period when there were neither sun-light nor atmospheric air to operate in producing those slow but gradual changes which now, apparently almost without the interference of any

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* See the 67th and 69th Theorems, and their evidences.

agency, are certain to be the consequences in any solution which is exposed to their influence. At the time to which we allude, neither the heating nor the chemical rays of the sun were shed upon the ocean, nor was it operated upon by the searching and all-pervading agency of the atmosphere.

Its causes of change, whatever they were, resided entirely within its dark and atmosphereless mass, and *there*, under the directive power of the Almighty, were made to produce those ends for which they were brought into being.

We shall, therefore, as the natural result of the law of equilibrium to which we have just referred, conclude, that water, chemically charged with extraneous ingredients, would, by parting with the *surplus* atoms of any one of them, assume that static condition by the mutual arrangement of the molecules *inter se*, according to their respective affinities; and that so long as none of these ingredients which remained were withdrawn, nor any other substance was added to them, the mass would continue in the condition of equilibrium which it had assumed.

It is stated, and with perfect truth, in the *sixty-seventh* Theorem: "*That one of the most important qualities of matter in mechanical investigation is* INERTIA, *or that property which results from its inability to produce in itself spontaneous change or action, either from a state of rest to that of motion, or vice versa, to diminish any motion which it may have received from an external cause, or to change its direction.*"

Now, when those two fundamental truths are brought into juxta-position in the mind, and we take into account the condition of our planet at that period, namely, "the Earth being without form and void, and darkness upon the face of the deep:" when we consider that we are treating of a non-rotating sphere enveloped in a dark, atmosphereless ocean of water, reduced, by the deposition of all superabundant earthy ingredients to a state of chemical equilibrium, and flowing—in obedience to the luni-solar attraction—in one unvarying current round the rocky crust which sustained it; but without this being able to produce the slightest change in its molecular composition—for every atom of water being equally brought to a state of chemical equilibrium, none could exercise

any influence over another—we must conclude, that the *inertia* of matter would be the governing principle of the whole. As long as there was no abstraction from the mass—and nothing could, under the circumstances described, be taken from it; or no new principle impressed upon it, or addition made to its constituent particles; or no external force brought to bear upon it—a change *could not by possibility have taken place.* The primeval water, once brought to a state of chemical equilibrium—and to that condition, as we have already shown, it must of necessity have come—no change could, or ever would, have taken place in the mass thereafter, *unless by the interposition of something beyond and external to itself.*

At this conclusion we have arrived by applying the announcements of science to the condition of the earth during the early age to which we allude; while it is worthy of being remarked, that in the Scriptures alone is any adequate account to be found of those conditions which the wonderful discoveries of after science—when carried back, as it were, and applied to the case in question—require, in order satisfactorily to solve the great and important problem of the geological phenomena. These discoveries demand, that there should have been a stage in the world's geological history, when its surface should have been devoid of form; when it should have been surrounded by water, and cloaked by universal darkness;—and these are declared in the simple but emphatic and comprehensive language of Scripture, to have been the actual circumstances of the earth, on the very first mention which is made of it, when introduced to our notice as "without form and void; darkness upon the face of the deep." When we take a deliberate and comprehensive review of the position which we have now reached in our argument, we shall have little hesitation in admitting, that it would be one of insurmountable difficulty were we to attempt to walk by the light of Science alone. A world without rotation—enveloped in an atmosphereless ocean—reigned over by universal darkness, and whose circumfluent water had, by the laws which regulate molecular attraction of affinity, reached a state of equilibrium; and, consequently, without some influence beyond itself incapable of alteration, are conditions which, contemporane-

ously operating, would, without the continuing influence of the Creator, have brought the work to a conclusion in that incipient and imperfect state. For, if we turn to the astronomer, he will, after consulting his well authenticated general laws, inform us, that consistently with those which govern the earth's orbital motion, there could have been no addition of ponderable matter made to it after it was translated in space; neither could any abstraction have taken place, without endangering the permanency of its periodical course. If, to the natural philosopher—rendered conversant, by deep and protracted study, with the laws of *inertia*—we next seek for aid, he will inform us, with that reliance which he has acquired by repeated experience, that "matter is incapable of producing in itself spontaneous change, either from a state of rest to that of motion; or of diminishing any motion which it may have acquired, or to change its direction:" that in fine, it is, as designated, wholly inert and entirely passive at the will of external causes. And, lastly, if we direct our enquiries to the chemist, in hopes that his minuter investigations, into the constituent elements of material substances and their affinities, may have furnished him with the knowledge necessary to relieve us from our embarrassments, we shall be met by still closer and more impassable barriers. We shall find that his laborious and intelligent investigations have clearly revealed to him, that the ultimate molecules of matter are governed by and obedient to the same law of inertia; their chemical affinities *being once satisfied* they never can, of *themselves*, thereafter change; they can neither increase, diminish, nor alter their own powers spontaneously.

Hopeless of success, the individual enquirer—who relies on nature alone being able to answer all the questions requisite to be put, in order to unravel the mystery—either turns aside from the arduous task, as one incapable of being satisfactorily accomplished, or rushes blindly into some wild and general speculations, wholly disregardful, not only of revelation, but of all well investigated laws of nature, revealed to us by modern science, in hopes that by some desperate effort he may be enabled to clear the dangerous gap which presents itself to impede his further progress. But those who are enabled to

recognise the utter helplessness of human knowledge to relieve them from such an embarrassment—to extricate them from this dilemma, and who, therefore, turn to the announcements of Scripture, will find, that in immediate sequence to that passage describing the static condition of the creation to which we allude, there is another which supplies all that is wanting; for it is written, "And the spirit of God *moved* upon the face of the waters."

It would be presumptuous to attempt to determine the period or its duration when, in the development of the great plan of creation, it was essential that this immediate FIRST CAUSE should be exercised. The only key we have to it is what is contained in the 1st and 2nd verses of Genesis. It is, however, our belief, as it will be our care to make manifest in the sequel, that the period of non-rotation was coeval and coexistent with it, and that the other attendant circumstances of the material universe were in perfect accordance with this announcement of the immediate act of Omnipotent power: while it must be conceded, that no being, except the Spirit of God, could have conducted a *progressive* operation to its destined end, whose ultimate condition of perfection was known only to God: for it is written, "No one knoweth the mind of God save the Spirit of God."

Although it may turn out, hereafter, that more laborious geological researches may carry back the era to a remoter period than what is at present conjectured, when fossil remains may demonstrate the existence either of inferior animals or of plants, still, we presume, we may, with safety, for all practical purposes, adopt the impressive language of Sir R. J. Murchison, and assert,

> "That the very genesis of animal life, upon the globe, has been reached by the indefatigable exertions of geologists; and that no further *vestigia retrorsum* will be found beneath the protozoic or lower silurian group, in the great inferior mass of which no vertebrated animal has yet been detected amid the countless profusion of the lower orders of the marine animals entombed in it."

And that it cannot be doubted, from the result of the rigorous examinations to which the primitive rocks have been

subjected, that there are entire formations in which no traces of the remains of organized existence (animals or plants), of even the lowest or simplest grades, have ever been discovered, their mineralogical structure revealing to us that crystallization was then the almost exclusive agent employed by the Creator to perform the work of preparation. And when we consider the minuteness and universality with which the encrusting process of crystallization would go on at the bottom of a tremulous, dark, atmosphereless ocean of shoreless extent, charged with all the elements most conducive to its advancement, we must admire the wonderful adaptation of the means to the end: while we recognize the wisdom which devised an agency of such universal efficacy, and a promoter of such a variety of pleasing and symmetrical forms; and be grateful for the goodness which induced the employment of an intermediate instrumentality between inert matter and organized existencies, that there might be abstracted from the water immense masses of mineral substances, which, had they been released from their chemical affinity with water by the instrumentality of animals and plants themselves, would inevitably have buried both beneath their vast accumulations: while at the same time, the minutest particles of matter, by being subjected to the peculiar elaboration required to polarize them and so to induce crystallization, became wrought into combinations which no other means could have effected; and, substances which otherwise would have been hurtful to after states of the creation, were thereby neutralized and locked up, in perfect innoxious security, for the future uses of the world's inhabitants.

The crystallization which is here mentioned, induced by *aqueous* solubility, although akin to that which was afterwards produced by *fusion*, from heat, arising from the friction occasioned by the movement *entre se* of the mineral masses of the earth's crust, when the sphere was first made to rotate around its axis, should be clearly distinguished, in its objects and effects, from this latter: aqueous crystallization having affected the stratified formations more exclusively, and having evidently been brought into operation at a different stage of the creation; indeed, long before crystallization from caloric induction

could have been made an agent, as it certainly was at its appropriate period, in the great work of the world's formation then going on.

Having so recently given the more particular evidences regarding aqueous crystallization and made these general remarks, we shall not now require to do more, with respect to this very interesting and modern branch of study, than to recapitulate what is stated in the *hundred and eleventh* Theorem, viz., "*That when substances are rendered fluid with perfect mobility amongst their particles, either by igneous fusion or by solution, and are suffered to pass with adequate slowness into the solid state, the attractive forces—called homogenous attraction—frequently re-arrange these particles into regular polyhedral figures or geometrical solids; to which the name of* CRYSTALS *has been given. That mere approximation of the particles is not, however, alone sufficient to produce crystallization, they must also change the direction of their poles from the fluid collocation to their position in the solid state, which may be effected by the following means, namely :—*1. *By vibratory motion, communicated either from the atmosphere or any other moving body.* 2. *By contact of any part of the fluid with a point of a solid of similar composition previously formed, or other substance.* 3. *By the slow and continued agency of voltaic electricity operating in water. That darkness in most instances favours crystallization. That heat, likewise, exercises considerable influence on these phenomena; and, lastly, that the same substance, in crystallizing, not unfrequently assumes a diversity of forms; though, in general, the same substance, under similar circumstances, assumes the same form.*"

The evidence afforded by this Theorem, founded upon the testimony of men who have made this branch of mineralogy their attentive study, leaves not a doubt on the mind as to the existence of a progressive power having been exercised over the particles of *mineral* matter, by which they became symmetrically arranged into crystals of adamantine hardness and brilliancy, in a manner precisely analogous to the arrangement we more frequently witness amongst the less adherent particles of neutral salts; and that all the conditions of the earth, at the period we allude to, as supposed in this theory, were precisely

those most conducive to foster and to promote the aqueous crystallization of mineral matter, on a scale commensurate to the magnitude of the design. Having arrived at this conclusion, it only now requires to be seen, *whether the mineralogical structure of the rocks, which constitute the basis of the Earth's crust, affords corresponding evidences of the silent, slow, and ubiguous work of this influential agency.*

To attain this end we shall recapitulate the words of the *hundred and twelfth* Theorem, in which it is stated, on the authority of those writers who sustain that proposition,

"*That most of the rocks which compose the mineral crust of the earth are in a crystallized state.* GRANITE, *for example, consisting of crystals of quartz, felspar, and mica;* MARBLE *of crystals of carbonate of lime, &c. And that the whole phenomena attendant on crystallization go to prove, that substances having the same crystalline form must consist of ultimate atoms, having the same figure and arranged in the same order, so that the form of crystals is dependant on their atomic constitution.*

In support of this abstract form of stating the subject, we shall take occasion to add a few descriptive extracts from the works of those who have favoured the world with the result of their interesting enquiries into this branch of mineralogical geology. M. de la Beche says—

"Granite is a confusedly crystalline compound of quartz, felspar, mica, and hornblende. . . . . It is occasionally porphyritic, large crystals of felspar being disseminated through the mass, showing that, however confused the crystallization may have been, circumstances were such as to permit the production of distinct crystals of felspar. Greenstone and the other rocks usually termed *Trappean*, vary in texture from an apparently simple rock to a confusedly crystalline compound, in which crystals of felspar are disseminated. . . . .

"Such are the rocks commonly considered unstratified. It will have been seen that they so pass into one another that distinctions are not easily established between them. Mineralogically, granite passes through various stages, and graduates into the compounds named greenstone and others of the trappean class."*

* De la Beche, pp. 486—489.

Mr. Lyell observes—

"We have now to examine those crystalline (or hypogene) strata to which the name of *metamorphic* has been assigned. The last term expresses a theoretical opinion that such strata, after having been deposited from water, acquired by the influence of heat and other causes a highly crystalline texture. . . . . . 'There are,' says Professor Sedgwick, 'three distinct forms of structure exhibited in certain rocks throughout large districts, viz., stratification, joints, and slaty cleavage, the two last having no connexion with true bedding, and having been superinduced by causes absolutely independent of gravitation.' . . . . . It has been observed by Mr. Murchison, 'that in referring both joints and slaty cleavage to crystalline action we are borne out by a well-known analogy, in which crystallization has in like manner given rise to two distinct kinds of structure in the same body.' . . . . .

"Sir John Herschel, in allusion to slaty cleavage, has suggested, 'that if rocks have been so treated as to allow a commencement of crystallization, or heated to a point at which the particles can begin to move amongst themselves, some general law must determine the position in which these particles will rest on cooling; and when this is the case it must of course determine a cleavage plane; this takes place in many of our chemical manipulations and in the arts, and what occurs in our experiments on a minute scale may occur in nature on a great one.' "*

"What, then," asks Professor Phillips, "is the fruit of all this discussion? It is the conviction that the gneiss, mica slate, primary limestone, quartz rock, &c., are stratified rocks, ... but that the causes which tend among all rocks to complicate the stratification with new structures, have gone to the maximum in these the oldest of all; the principal of these causes being heat, either locally exhibited in the neighbourhood of igneous crystallized rocks, or generally pervading the whole mass of deposits."†

The following corroborative testimony is from Mr. Ramsay's admirable little Treatise on the Geology of Arran; an island, our readers are aware, which presents great facilities for such investigations:—

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* Lyell's Elements of Geology, vol. ii. pp. 379, 400. Silurian System of Rocks, p. 246.

† Treatise on Geology, p. 75.

"The mass of the granite of Goatfell is the large grained variety; but there are found in it many veins of a fine, compact texture, which indeed are common throughout all the coarse grained granite of Arran. . . . . . The constituent parts of the latter are felspar, quartz, and mica; and the differences in texture are owing to the variable proportions and sizes of these constituent minerals. Generally the felspar predominates, next quartz, and lastly mica, in comparative small quantities.

"There are three varieties of felspar, the first of a light brown colour, the second almost pure white, and the third, commonly called glassy felspar, exhibiting a brilliant polish when fractured. . . . . . Of the quartz there are also several varieties, viz., common white quartz, pale yellow, light grey, colourless quartz, or pure rock crystal; light brown, dark brown or smoked quartz, and sometimes, though rarely, it is almost black. . . . . . The transparent and dark varieties are by no means rare, and frequently attain to a considerable size. They are usually found in the form of hexagonal prisms, and occur along with crystals of felspar, in those rounded cavities which are so common in this granite. Specimens are also found, in which the transparent and light grey varieties alternate in layers, like the various colourings of an agate.

"The mica is much more sparingly diffused than the other minerals, and is usually found in small scales of a dark brown or black colour. The fine grained granite does not occur in mass in the neighbourhood of Goatfell, being only found in the form of penetrating veins. . . . . Wherever it penetrates the coarse granite in veins, there it exhibits the finest and most compact texture, and frequently the quartz and mica totally disappear, leaving the remaining constituent in the form of a compact felspar.

"The phenomenon of its superior fineness in the veins is easily accounted for, when it is considered that when the melted matter forced itself into the fissures in the coarse grained or older granite, and thus came in contact with a cooling substance (the coarse granite being previously consolidated), it would crystallize more rapidly, and consequently in smaller crystals, than if the cooling process were more gradual. In this granite mica is only to be found in very small black scales, sparingly intermingled with the quartz and felspar. The two latter constituents are sometimes mingled in nearly equal proportions, but very frequently the felspar predominates."*

* Geology of Arran, by Andrew C. Ramsay, pp. 5, 6.

The universal and sustained agency which we have thus been made aware was going on throughout the primeval ocean, forming into solid masses many of its elements, and constituting them into the rocky barriers which afterwards were to confine the waters themselves within their destined limits—when the great plan of Creation should be more fully developed—would, by disturbing the chemical equilibrium, to which such frequent allusion has been made, release other earthy ingredients by the extraction of those particles which formed the crystals; whilst the mechanical deposition of of those elements, thus liberated, would confer on the conjoint formation a confusedly crystalline texture.

Were it essential, it might be easy to show that the continued action of a single agency, such as the one here alluded to—however searching and universal it may have been in its effects upon impregnated water, so well calculated to promote them—would have again brought the entire aqueous body into a static condition of equilibrium; and have occasioned the necessity of introducing some *new* power, in order to perpetuate the work of deposition, which, in that epoch, it seems to have been the design of a beneficent Creator to accomplish. Fortunately, however, we are spared the necessity of this investigation. The fossil exuviæ of inferior classes of animals and plants which are found imbedded, nay, partly constituting the very rocks themselves, sufficiently attest this great truth, and show us that besides crystallization—which may be looked upon as an earlier means of transforming those aqueous compounds into solid matter—there were other scarcely less ubiquous, silent, and indefatigable agents employed in this great work of solidification; and which, while they were progressively increasing, and some were encrusting themselves with shelly coverings of carbonate and phosphate of lime, and others with ligneous fibres, were all alike fulfilling the decrees of Providence, and preparing the earth and the water for their relative fitness and position when they should, by the diurnal rotation of the sphere, be finally transformed into "the habitable globe," the solid portion rising to restrain the purified aqueous part within the bounds which appear to have been from the begin-

ning designed for it. Nor should it be overlooked that it was only from such a source as the life-giving Creator that this new principle of animal and vegetable vitality could have been derived; and that He alone could thus interpose an effectual and successive agency to interrupt the state of equilibrium which the water would otherwise have inevitably assumed.

Were it not that we are engaged in the rigid task of endeavouring to explain these wonders, and bent on convincing the understanding, not in working merely upon the imagination, we should feel an irresistible desire to ponder over and admire the amazing stretch of wisdom and of power, which, by means apparently so simple could effectuate ends so vast, and designs so beneficent; could cause those comparatively insignificant instruments to drain the primitive ocean of elements which, in other states, would have proved injurious; and could, with the matter thus solidified, form that which in due time was to set bounds to the water, which, with shoreless expansion, had circumbounded the whole earthy nucleus! But we have not yet gained so firm a resting-place in our argument as to admit of our pausing to expatiate on the never-ending themes of admiration which lie before us, and therefore, while we keep that in reserve for hereafter, we must proceed with the chain of our present argument.

It is so entirely in accordance with the manner of the growth of plants, and with that in which the lower apulmonic tribes of animals and zoophytes propagate, to extend themselves from centres or foci, that it need scarcely be particularly proved. Those centres would, of course, be originated where it was foreseen by an Omniscient Creator to be most conducive, for the ulterior development of His plans, to place them. It would be alike superfluous and inconclusive were we to occupy our time or attention surmising *where* they did commence; or whether animal life preceded vegetable existences; whether the reverse was the case, or whether they commenced simultaneously. The conflicting opinions of geologists, although deduced alike from the organic remains of the respective divisions, would seem to leave the field open to those who surmise that both may have had the dawn of their existence on our

planet at the same period,* although at first, in number and variety, the objects of the animal economy—which seem to have been willed into existence together—far exceeded those of the vegetable kingdom; but, in the course of ages, those of the latter great division (the plants), gained upon the former, until at length, about the period when the light was to be formed, and the earth made to rotate around its axis, or when the great coal fields were being stored with ligneous deposits, *vegetable* greatly surpassed the proportion of *animal* life. The stereotyped remains of each of those classes of existences pertaining to the inferior branches of their respective kingdoms, enable us still to read, with almost unfaltering precision, the history of their bygone but essential labours at the bottom of a dark and boundless ocean of considerable depth, and charged throughout with the materials we have so often alluded to, held in firm chemical combination by the aid of associated gaseous elements

When treating of this particular point, we must not overlook the important testimony afforded by a late writer regarding the early dawn of animal life upon the globe.

> "It is important to remember," says he, "that almost all the great natural divisions of the invertebrata began at once and together to perform their work on earth. . . . . . There are no appearances of any regular order of succession. . . . . They seem to have been truly contemporaneous, and doubtless introduced as the group best fitted to perform the functions of their existence."†

It is when we look upon the subject in this point of view, that we behold with greater vividness the combination of wisdom, and benignant goodness which characterized all the proceedings of the Creator: for, while those animals, zoophytes, and plants were abstracting from the water that which was necessary to be taken from the primitive ocean, before it could be made the seas of the present day, they were drawing

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* It appears to be Dr. Buckland's opinion, that the creation of marine animals and plants were contemporaneous, and that both commenced in the lowest transition stratified masses.—Bridgewater Treatise, vol. i. p. 18.

† Ansted's Ancient World, pp. 47—51.

down the material to the bottom, and encrusting with it, through their own bodies, film after film, as it were, the vast submarine surface of the earth, and causing it gradually to expand to its destined size, preparatory to its future change of posture; while, during the whole process, those successive creations were each fulfilling to the uttermost the functions of their limited career of existence, and deriving therefrom whatever satisfaction they were capable of enjoying. Why it should have seemed good to an all-wise and Omnipotent Creator thus gradually to have introduced the living principle into the material universe, and to have adopted this protracted method of "creating the materials of the heaven and earth at the beginning," is not for us to enquire; nor are such enquiries within the scope of this work, even were it within our power to accomplish such an undertaking. The organic remains, which everywhere exist, afford undeniable evidences that it pleased him to do so, to restrain for a time, as it were, his creative influences, and to lavish the riches of his goodness and providential care on classes of animals and plants apparently so insignificant, and comparatively incapable of either enjoying or appreciating those bounties which he conferred upon them; while, on the other hand, the knowledge of his revealed attributes affords sufficient assurance, that whatever did then exist was that which was most consistent with those attributes; and that when the Creator beheld them labouring to accomplish his will in their dark and profound abodes he could have declared—although it has not pleased him to reveal it to us—that their work also "was good."

When treating, in the Second Section, of the animal existences of that period, we were made aware that by means of the corium and other secreting membranes, they fabricated to themselves coverings of carbonate of lime, cemented together by a small portion of animal gluten.* We were also shown, that their testaceous and zoophytic remains are of immensely greater dimensions than any belonging to recent equivalents. We likewise know that the existence of the organized exuviæ proves, to a certainty, the existence at one

* 136th Theorem.

time of the animal inhabitants, while the known relation of the animal to its covering, demonstrates their excess in size beyond any of their living congenors. "That, besides the three elements, oxygen, hydrogen, and carbon, which plants and animals alike contain, the latter generally have more azote or nitrogen in their composition,"* and that these apulmonic animals and zoophytes, from either being fixed, or of restricted motion, were wholly dependant on the surrounding fluid for their sustenance.†

Combining all these essential circumstances together, we have, as a clear deduction, that the effect upon the primeval ocean of animal drainage alone, through numberless ages, was *to abstract from its water a quantity of matter equal to the aggregate mass of their shelly coverings, and of those parts of the animal bodies which, after their death, did not re-enter into the circulation then going on.* And, lastly, that the elementary materials thus withdrawn from the primitive ocean, by animal chemistry and agency, consisted of carbonic acid (oxygen and carbon), and lime (calcium and oxygen), to form their testaceous and zoophytic coverings; and of carbon, oxygen, hydrogen, and azote to constitute their animal bodies.

With respect to the no less active and extended agency of *vegetation* in effecting the object we now allude to, sufficient has already been explained to show, that enormous cryptogamic and allied plants of different families abounded and were influential in producing the changes which took place throughout the whole period of non-rotation, and more especially during the formation of the coal series; and as we are authorized, both by analogy and by the nature of their remains, to consider their constituent elements to have been oxygen, hydrogen, and carbon; so we conclude that *for all of these, as well as for whatever they, through their roots, deposited in the soil, they must, from the very nature of the attendant circumstances, have been wholly dependant on the surrounding medium.*

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* Animal Kingdom, by Baron Cuvier. Edinburgh. Preface to Nat. Hist. pp. 17, 18.

† Dr. Fleming's Work on British Zoology.

In fine we may assume, that there were abstracted from the primitive water, by vegetable agency and secretion, all the materials which constitute the carboniferous portion of the terraine formations; or, in more general terms, all that which went to form the sub-marine vegetation of the earth during the protracted period we allude to—less the elements which, after the plants were deprived of the principle of vegetable life, re-entered into circulation, and became parts of new combinations; while, to complete this conception, it should be kept in mind that, at the bottom of a deep and atmosphereless ocean, the gaseous exhalations which escaped from decaying plants would be infinitely less than under the circumstances which attend their decomposition in the present state of the earth.

The ultimate result of the combined secretions by animal and vegetable agency, *must have been to have abstracted from the* PRIMITIVE WATER *elementary materials equal to all the organic matter which owes its origin to these two sources :* a conclusion which is quite undeniable, and of which we shall avail ourselves hereafter by combining it with others, equally well-substantiated.

The efficacy of the instrumentality thus brought to bear upon the universal menstruum, can only be sufficiently estimated when the vast extent and great depth of the aggregate deposits, which mainly owe their existence to animal and vegetable remains, are taken into account; and when the impression is properly borne in upon the mind of the efficiency of numbers, we might say of myriads, in combination, when they are substituted for *individual* power however great.

To convey an adequate conception in a few words of the actual results of the means then employed is impossible; we shall, therefore, as usual, have recourse to concise extracts from the writings of those indefatigable men, who, by their researches, have done so much for this branch of science, and have contributed so essentially to the elucidation of this part of the earth's history.

"The carboniferous limestone," says Sir Henry de la Beche, "in the South of England, Wales, the North of France, and Belgium, seems to possess a somewhat similar general character, being a com-

pact limestone, frequently traversed by veins of calcareous spar, at times appearing to be in a great measure composed of organic remains, while at others not a trace of these remains can be observed.

"It is occasionally of an oolitic structure, and sometimes contains parts of encrinal columns, in such abundance that the rock is, in a great measure, made up of them, whence the name *Encrinal Limestone.*"*

"Some of the beds of the carboniferous limestone," writes Dr. Ure, "are so pure as to contain 96 per cent. carbonate of lime; but by foreign admixture it passes into magnesian, or ferruginous, or bituminous, or fetid limestone. Its beds are commonly very thick, extending in a continuous series many hundred feet in depth. Many species of testacea or shell fish begin to appear in the carboniferous limestone; but they, all along, belong to a very few genera; while the zoophytal families (polyparies), particularly encrinites and corallites, exist in the greatest abundance. . . . . From the profusion of encrinites, this species of limestone has often been called encrinal. The coralloid remains are caryophylea, turbinolia, astrea, favočites, tubipora, and retipora."†

"The lowest, or 'mountain limestone,'" observes Dr. M'Culloch, "under various names, immediately follows the 'old' red sandstone, having been formerly considered a transition rock by foreign geologists. The beds are often of great thickness, and the series of considerable depth; yet, at times, the reverse; while they occasionally include thinner strata of clay, shale, and arinaceous rocks, which, in some places, becoming more prevalent, materially affect the calcareous character of this deposit. The limestone itself is sometimes pure, approaching to the crystalline texture; while, at others, it becomes argillaceous, magnesian, ferruginous, or bituminous."‡

"It is a difficult problem," states Professor Buckland, "to account for the source of the enormous masses of carbonate of lime that compose nearly one-eighth part of the superficial crust of the globe. Some have referred it entirely to the secretions of marine animals; an origin to which we must obviously assign those portions of calcareous strata which are composed of comminuted shells and corallines; but until it can be shown that these animals have the power of forming lime from other elements, we must suppose that they derived it from the sea, either directly, or through the medium of its

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* Geological Manual. † Dr. Ure's Geology, pp. 175—178.

‡ Gelogy, by Dr. M'Culloch, vol. ii. p. 238.

plants. In either case it remains to find the source whence the sea obtained, not only these supplies of carbonate of lime for its animal inhabitants, but also the still larger quantities of the same substance that have been precipitated in the form of calcareous strata."*

"The most prolific source," says the same author, "of organic remains, has been the accumulation of the shelly coverings of animals which occupied the bottom of the sea during a long series of consecutive generations. A large proportion of the entire substance of many strata is composed of myriads of these shells reduced to a comminuted state, by the long continued movements of water. In other strata, the presence of countless multitudes of unbroken corallines, and of fragile shells, having their more delicate spines still attached and undisturbed, shows, that the animals which formed them lived and died upon, or near, the spot where these remains are found.

"Strata thus loaded with the exuviæ of innumerable generations of organic beings, afford strong proof of the lapse of long periods of time, wherein the animals from which they have been derived lived and multiplied, and died, at the bottom of the seas, which once occupied the site of our present continents and islands. Repeated changes in species, both of animals and vegetables, in succeeding members of different formations, give further evidence, not only of the lapse of time, but also of further important changes in the physical condition and climate of the ancient earth."†

"Successions of strata, each many feet in thickness, and many miles in extent, are often half made up of the calcareous skeletons of encrinites. The entrochial marble of Derbyshire, and the black rock in the cliffs of carboniferous limestone near Bristol, are well-known examples of strata thus composed, and show how largely the bodies of animals have, occasionally, contributed by their remains to swell the volume of materials that now compose the mineral world."‡

"The remains of organic existences," according to a late continental writer, "reveal to us that entire formations occur wholly composed of the fossil relics of animalculites. To Ehrenberg we are indebted for the development of the fact, that ages ago our world was rife with these minute organisms, belonging to a great number of species, whose mineralized skeletons actually constitute nearly

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* Bridgewater Treatise, vol. i. p. 89. † Ibid, p. 116. ‡ Ibid, pp. 416, 417.

the whole mass of some tertiary soils and rocks several feet in thickness, and extending over areas of many acres. The size of a single one, forming the polishing slate, amounts, upon an average, and in the greatest part, to one two-hundred-and-eighty-eighth of a line. As the Polerschiefer of Bilin is slaty, but without cavities, these animalcules lie closely compressed. In round numbers, about 23 millions would take up a cubic line, and would, in fact, be contained in it. There are 1,728 cubic lines in a cubic inch, and, therefore, a cubic inch would contain, on an average, about 41,000 millions of these animals. On weighing a cubic inch of this mass, I found it to be about two hundred and twenty grains. Of the 41,000 millions of animals, 187 millions go to a grain; or the siliceous shield of each animalcule weighs about a hundred and eighty-seven millionth part of a grain."

A modern author, who has given a great deal of attention to fossil remains, when treating of those of the silurian or first epoch, assures us, that

"Polyps—as animals of this low organization are called—appear to have been among the first of created beings, and are also those which have changed least up to this present time. . . . . . They seem to have been comprised within a very limited number of natural families, and some particular species probably extended through the whole number of beds of the first great epoch. . . . . . During every successive period, from this their first appearance in the infancy of the world, to the present, these polyps have been adding to the solid matter of our globe by their singular buildings of stone. . . . . . These little creatures are enabled to separate from the seawater a proportion of carbonate of lime, used in constructing their stony encrustations; and they do this, although the quantity present is so minute as to be almost inappreciable by the most careful chemical analysis. . . . . . . They secrete the calcareous or stony coverings on the outside of their soft bodies, and some of them form themselves into compounds resembling trees, with root, stem, and branches, composed of separate and detached particles. The *Encrinites*, *Sphœronites*, and *Pentacrinites* are remarkable examples of this, one individual of the former being made up of no less than 30,000 separate particles of stone, while one of the latter contains 150,000 minute pieces of the same material."*

* Ancient World, by Ansted, pp. 27—31, 118, 119, 137.

These extracts—a tithe merely of what might have been given—together with our explanations of the subject, will, we trust, have sufficiently shown the attributed origin and construction of the calcareous formations, some of which underlie and admirably protect the coal measures.

When we contemplate these calcareous rocks in a more general, and at the same time, relative point of view, they will be found to exhibit, in a very remarkable manner, that wonderful wisdom so manifest in all the works of the Creator.

Besides the intrinsic and almost unlimited value of these mineral treasures to man, as a material subministering to his use and comfort, and as the chief repository of many of the metalliferous ores, the testacea and zoophyta, which, by their indurated remains contributed so essentially to the construction of the calcareous deposits, imparted, at the same time from their molluscous parts, a peculiar ingredient which enters very materially into the composition of coal. In the calcareous formations were bound up, in a perfectly harmless condition—within the reach and at the will of man—noxious and superfluous gases, in union with earthy and insoluble bases, whereby the primitive water not only became cleansed of those life-destroying elements; but they, hurtful as they are in themselves, were also transformed into deposits of useful material for the wants of races destined afterwards to inhabit the Earth, and into solid barriers to restrain the ocean within the bounds assigned to it: a provision of gracious forethought, whereby these elements were rendered *always useful and innoxious* to the very different races of living beings which seem to have been destined to people the Earth at successive periods of its creation.

No less admirable was the adaptation of the calcareous deposits in a *relative* point of view. In this respect, aided by aluminous admixture (the best non-conductor of heat among minerals), they performed the important office of a *great lining formation* to defend the coal measures from the action of those intense heats which were engendered by the first rotation of the Earth; and which, without this almost impervious defence underneath the great body of the coal, would have driven off, by fusion, the essential bitumious portion, and left the exten-

sive coal measures of the world as indurated, and perhaps, more unserviceable than the hardest anthracite; which, occurring in small portions at the points of contact and fusion, have left us specimens of what would, otherwise most probably, have been the inevitable result throughout the whole extent of the coal series.

And finally, the great underlying calcareous formation—marked by the bold callygraphy of fossilized remains—reveal to us by those enduring characters, which can neither be set aside nor misunderstood, that ages before the principal accumulation of the vegetable remains which constitute the coal measures, the solid portion of this sphere teemed with animal life, with beings of apulmonic description, and of the kinds so elaborately classified by geologists, who have given their attention to the subject, from whose writings we have hitherto derived some of our most efficient evidences, and to which we intend to recur for more as we proceed with our discourse.

Now, wherever are found calcareous shelly coverings of an organic structure, *there* the animal fabricators and inhabitants must, also, at some time have been; but, existing no longer, they must, after death, have become subject to the all-pervading laws of decomposition and chemical affinity; consequently, in the progress of their decomposition, have given rise to those results which have been so well explained by the writers from whom we have so frequently and fully quoted. For, wherever the efficient causes were, there the results would inevitably follow.

In a former part of this work it was shown that there was a succession of inferior animal life in the primitive ocean; and if a succession, then an adaptation of being to the various changes which the water underwent.*

It may be well to have these facts present to the mind, while, amidst the difficulties which arise from the uncertainty that still prevails as to the sequence of, and influence exercised by, electric chemical attraction when several ingredients are held in simultaneous solution; from the variations of temperature,

* In accordance with the 135th Theorem.

and the unknown amount of these; and from the effects of the immensity of the body of the water employed, we endeavour, notwithstanding these formidable objections, briefly to explain how we consider that the several ingredients (many of which are of themselves insoluble in water), may be supposed to have been held in chemical suspension by the primitive ocean.

Silex, the most abundant of those earthy ingredients, is wholly insoluble in water in the state in which it is generally found deposited. Alumina, however, unites with it in the humid way, and renders silex soluble in acids, an effect which barytes also exercises over it.* Muriatic acid dissolves a small portion of it when finely comminuted; and fluoric acid dissolves it either when the acid is gaseous, or when combined with water.† And, it is asserted, on the authority of Berzelius, "that when newly oxygenated it is extremely soluble."‡ Without attempting to investigate when and how its base was, at first, brought into contact with oxygen, and thereby became oxygenated, we are authorized to infer, that being now in actual union, there was a time when it was "newly oxygenated," and that *then* it was soluble and impregnated with the gases mentioned above. At that time water must also have existed. A combination of these facts will enable us to conclude, that it may have been dissolved and remained soluble in the primitive water from the period of its having been newly oxygenated.

Alumina—the next abundant earth in nature—although of itself not soluble in any sensible degree in water, yet its compounds are soluble in every possible proportion. The salts of alumina, formed by its union with muriatic, carbonic, sulphuric, and nitric acids, especially the first, are all abundantly soluble in water. It is likewise rendered soluble by the fixed alkalies, and by barytes and strontites, and therefore its solubility in the water of the primitive ocean, where all those existed in profusion, is very easily accounted for.

Magnesia may be considered pretty much in the same

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* Murray, vol. ii. pp. 71, 98. † Ibid, p. 111. ‡ Ibid, p. 108, and Dr. Ure, p. 743.

relative circumstances as the last-mentioned earth; for although its carbonate requires two thousand times its own weight of water to dissolve it, yet, as the salts of magnesia arising from combination with either muriatic, nitric, or sulphuric acids are extremely soluble, there can be little difficulty in conceiving it to have been held in solution in its states of a muriate, or of a sulphate, and the less so when it is considered that in those combinations it still exists, to a certain degree, in sea water.

LIME, which, in regard to prevalence in the earth's crust, occupies the third place, is of itself rather insoluble in water, for this, at 60° of temperature, only takes up $\frac{1}{656}$th part of its own weight. Its carbonate is also nearly insoluble, and its sulphates require nearly 500 times their own weight to dissolve them. But as a muriate and nitrate it is extremely soluble, and abounds in these states, especially the former, both in the waters of many springs and in the ocean; consequently its solubility in the primitive ocean must be readily admitted. *Lime* presents the remarkable anomaly of being less soluble in warm than in cold water; water at 60°, when the temperature is increased, deposits part of the lime which it could have sustained at the former degree.*

ZIRCONIA and GLUCINA—earths but sparingly found in nature—though not soluble when united with carbonic acid, yet are soluble when combined with either muriatic or nitric acids, consequently their solubility may be considered likewise established.

SODA and POTASH, fixed alkalies, possess great affinity for water, and are not only soluble in it themselves, but so, likewise, are the salts which they produce by combination with the acids abovementioned. They materially aid the solubility of other substances, and in aqueous potash even the oxides of many metals, such as lead, tin, manganese, zinc, &c., become soluble—a fact of great value in enabling us to follow out this enquiry.†

The ACIDS are not only extremely soluble in water, but

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* Murray, vol. ii. p. 83.

† Ure, p. 691.

some of them are absorbed by it to the extent of many times its own bulk.*

Muriatic and sulphuric acids act on the metallic oxides, and also form soluble salts of iron, copper, tin, and zinc; sulphuric acid forms one of manganese; and carbonic acid does the same with iron; and by this we are enabled to account for the solubility of those otherwise refractory substances.

Having thus summarily accounted for the solubility of those various ingredients in the primitive ocean, it next becomes necessary to attempt some explanation of the manner in which it is supposed they could have assumed such a state of equilibrium as would have required either some abstraction from, or addition to, the general menstruum, before any precipitate could have taken place.

Had the earthy substances which were employed in this vast laboratory all severally exercised the same degree of affinity for the acids there present, or reciprocally for each other, the state of equilibrium, to which we have so often alluded, would have been utterly unattainable. The simple ratios of affinity of several of them, however, have been accurately ascertained, and are well-known to differ very materially.† It is, therefore, natural to suppose that, being all present simultaneously in the general menstruum, they would arrange themselves according to those affinities, until they had found their level, and attained those partial states of equilibrium

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* Hugo Reid, p. 108.

† For example:—sulphuric acid has a greater affinity for baryta than for potash, for potash than for soda; while this latter alkali is succeeded in order by lime, magnesia, ammonia, and alumina. (Ure, p. 184.) *Lime* has a greater affinity for muriatic and sulphuric acids than for carbonic acid, while it exceeds either potash or soda in affinity for the latter. *Potash* has a greater affinity for water, for carbonic acid, and indeed for all examined substances, than *soda* has. Soda exercises a greater preference for carbonic than for muriatic and sulphuric acids. (Idem, p. 756.) The fixed *alkalies* neutralize all the salts of ammonia, while this, in turn, neutralizes nearly all those of alumina. (Ibid, p. 141.) *Ammonia* has also greater affinity for carbonic than for muriatic acid. Muriatic, nitric, and sulphuric acids, together with aqueous potash, act on the metallic oxides; and the alkaline earths, when combined with carbonic acid, are insoluble, although the alkalies themselves, when so combined, are soluble.

from which no change could have taken place without some abstraction from or addition to the general mass.

We think our reasoning on this point will receive much confirmation when we reflect that the seas *have come* to a static condition of equilibrium; that they maintain this now in their normal or finished state, incapable of ever being again disturbed; while it is just as conceivable, that during the progress of their arriving at this ultimate stage of equilibrium, they may—nay, indeed, we know they must—have passed through several intermediate stages of partial equilibrium, from which they could only have been aroused to renewed progress of purification that they might assume their ultimate state, by some such agency as we have so often alluded to. While the general though feeble affinity of water itself (the vastly predominant element in the whole mass) to one and all of those substances, which we have shown could, under certain forms, be held in solution in it, would greatly tend to allow of perfect freedom of motion amongst the variously relationed elements, and admit of their uniting with facility according to their several affinities.

At the same time it should be remembered, that the gaseous elements now composing the atmosphere were, as yet, incorporated with their parent water, and would confer upon this latter vastly increased facility to solve and to retain other ingredients.

We have only now to repeat the example we formerly gave of water—even in the present day, with infinitely reduced powers of solution and absorption—holding in simultaneous combination ingredients somewhat similar to those which we are constrained to consider did exist in the primitive ocean. We allude to the mineral water of Carlsbad, which is found to consist of sulphate, carbonate, and muriate of soda; carbonate, fluate, and phosphate of lime; carbonate of strontia; carbonate of magnesia; phosphate of alumina; carbonate of iron; carbonate of manganese; and silica.*

Let it be supposed, therefore, that the primitive ocean,

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* Annals de Chim. xxi. p. 248.

charged, as we have considered it to have been, with earthy, alkaline, and gaseous elements, had assumed one of those stages of partial equilibrium; and that no further deposition could have taken place until either some abstraction from or some addition to the general mass had been made. A *spontaneous alteration*, it has been shown by reference to the law of inertia, *could not possibly have occurred*, and it was, therefore, indispensable that an agency, possessing powers independent of inertia, should be employed; or, in other words, that the universal menstruum should be acted upon either by crystallization, or by the principles of animal or vegetable life; *consequently, in either case, requiring a specific act of creative power.* Presuming the intention to have been to tenant the bottom of this immense laboratory with innumerable animated agents endowed with faculties adapted for absorbing, decomposing, assimilating, and recombining the elements which were suspended in the universal menstruum, whereby many of these elements became locked up; the results alluded to, all alike dependent on animal energy, would naturally ensue during their lifetime; and after their death, the elements so absorbed and elaborated would be restored to the water in modified combinations, and with certain peculiar additions which animal secretion alone could bestow upon it. Thus there would be a continual and an intricate circulation maintained in the primitive ocean from as many points, along the whole extent of its base, as there were mouths and stomatæ in the aggregate of its testaceous and polypiferous inhabitants, and its vegetable existences. It appears, also, from undoubted evidence, that those operations were carried on by a succession of races each adapted to the surrounding media of its day, and that they were continued in a similar manner through many ages, whose duration, together with the multiplicity of points and currents, would amply compensate for the small amount of work accomplished by each individual agent, and the minuteness of many of those employed.

In order to simplify our subject as much as possible, we have, in the foregoing, alluded chiefly to the effects of inferior animal life; but our readers should remember that a succession of events and effects precisely analogous were almost simulta-

neously taking place by means of the vegetative functions of imperfect orders of plants, of which we shall have occasion to treat more especially in the sequel.

Meantime, we have to observe, that in very many instances the fossil testacea and conchifera greatly exceeded in size many of their recent equivalents, and that entire calcareous formations are composed almost wholly of encrustations of the exuviæ of testacea and conchifera, whose coverings consisted of carbonate of lime amassed together by animal gluten.

It has also been explained, that carbonate of lime is composed of carbonic acid and lime, which in their combined state are wholly insoluble in water; consequently, by means of this universal carrier, and the constraining animal agency referred to, those two ingredients—one of which in large volumes is very injurious to animal life—became reciprocally bound up; were rendered innoxious to the more perfect races which were afterwards to follow; and were stored up for the future uses of man, whose intelligence alone could disunite and apply them to his own purposes.

Significant as this is of the unbounded goodness of Providence in thus providing for his creatures, it was not this view alone of the case to which we intended to direct the attention by reminding our readers, "*that the shelly coverings of those testaceæ and conchiferæ were composed of carbonic acid and lime, forced into union by their animal chemistry and elaboration,*" but to bring out another very striking manifestation of the wisdom which pervaded the whole work of Creation. According to the well-ascertained affinity which lime exercises towards the various acids—several of which were known to exist in the primitive ocean—there is none with which it would not *sooner have spontaneously united, than with carbonic acid;* and, consequently, had the constituent elements been allowed to combine as their affinities would have induced them, it is evident that so long as there remained within a combining distance, an unappropriated volume of muriatic, nitric, sulphuric, or, indeed, any other acid, no spontaneous combination between lime and *carbonic* acid would have taken place. *No carbonate of lime would have been formed.* In order to separate lime from its combination with muriatic,

nitric, or sulphuric acid, to which it has so strong an affinity, and cause it to combine with carbonic acid, *the application of a force beyond chemical affinity was essential*, and that power was provided, by the faculty having been conferred on the testacea, conchifera, and zoophyta, to abstract those elements from the surrounding medium, and to elaborate them into carbonate of lime, to constitute their calcareous coverings. The fact, itself, of their union has been established beyond a doubt.* The motive which induced the Creator so to order the chemical affinites that this animal agency should be indispensable, may not, at first sight, be quite so apparent; but when we submit, in our researches, to a constraining conviction of the fitness of the means adopted, on all occasions, by the Omnipotent, to the end which He has in view; and bring to mind the perfection of the attributes which, in union, guide His determinations, we shall be ready to confess that beneficence towards His creatures must have prevailed throughout the whole.

When we are made aware of the importance in the development of the great plan of Creation, of certain elements which appear to have been capable of being produced only by animal secretion; and remember the necessity of the elaborators being provided with coverings of some hard material insoluble in water, to protect their molluscous bodies from the pressure of the ocean; and add to these that, while assiduously working out the Creator's will, they were enjoying as much pleasure as their restricted powers and inferior animal life were susceptible of, we may obtain a glimpse, faint though it be, of some of the motives which seem to have induced their being called into existence, and employed for ages to do the Creator's work at the bottom of the primitive ocean; while their comparative fixity, and limited degree of animal sensation, adapted

* We have just been informed by a competent and impartial authority, that the polypiferous and mollúscous inhabitants of the ocean possess the faculty of abstracting lime from the surrounding briny element, even though it should exist only in proportions so minute as to escape the most searching chemical test; and we have also seen that they can elaborate it into particles of such tiny proportions that hundreds of thousands of them are required for the construction of an animal not larger than a usual sized lily.

them more peculiarly to the situation they held, and fitted them for the labour they had to perform.*

If it were admitted, that in some relative positions of the associated elements which were held in solution by the primitive waters, *lime* would be more difficult of abstraction, that is, that it was held in firmer affinity by some of the acidulous states of the ocean, than at other times, and by other states of it, then we might thereby easily account for the succession, in many instances apparently *gradual* changes of animal life; it being necessary under these circumstances, in order to carry on the work in progress, that there should have been formed new races of creatures, possessing greater powers of abstraction than their predecessors, and better adapted for overcoming the greater resistance which lime evinced to separate itself from its acidulous associates.

It should not be altogether overlooked, either, that even although they had been supplied with the nutriment which they required, death would frequently be taking place amongst those mollusca and zoophyta;† and that the gaseous exhalations which, as will be seen more particularly in the sequel, would arise therefrom, would, by separating certain earthy elements from others with which they were associated, cause the deposition of as much earthy and metallic bases as those gaseous exhalations were capable of releasing and precipitating.

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* We have motives for conjecturing that during the period of non-rotation the Creator was causing to be elaborated, besides those parts more discernible by our senses, the materials which, in due time, and by His sovereign mandate, should constitute the etherial fluid or primitive light, to be "stretched forth as a curtain" when the other parts of the wonderful work were in a suitable condition to be combined with, and acted upon, by this second all-pervading law of materialism.

† It will be observed, that we assume *death*, or *extinction of animal life*, to have been a prevailing law during the period of non-rotation, ages prior to the Mosaic week. Occular demonstration, arising from the every where abounding exuviæ of living forms convinces us of this. We have, besides, the authority of sound inference to lead us to the same conclusion; for, had our first parents not understood the full signification of the denouncement contained in the words, "in the day thou eatest thereof thou shalt surely die," this gracious warning of their contingent doom would not have been made use of to exercise that salutary influence for which it was evidently designed.

The *small* continued doses of ammonia, which would arise from the decomposition of their bodies, and ascend by lighter specific gravity, would also contribute more effectually to this than if those exhalations had been more abundant; for more powerful doses of ammonia are found to re-dissolve the precipitate.*

Without tarrying at present to enquire into the cause of the progressive increase of the temperature of the primitive ocean, but assuming this to be a fact established beyond a doubt,† we shall apply it to a point equally well ascertained in chemistry, namely, that water, when heated beyond 60° of Fahrenheit, deposits part of the lime which it can hold in solution at that degree of the thermometer. Or, in other words, "that lime possesses the remarkable anomaly of being less soluble in warm than in cold water." This may, perhaps, in part account for what has hitherto appeared so inexplicable, namely, the increase of calcareous formations, up to a certain point, according as they approach the present era, lime abounding more in the upper than in the lower formations. Agreeable to the laws which regulate animal functions and life, its gradual and progressive increase will, most probably, account for the remainder of this excess of lime in the newer, when compared with the older series of rocks; while, what has been said on the subject, altogether, may serve as an imperfect indication, and point the way to a more successful explanation of the manner in which the whole of the GREAT CARBONIFEROUS LIMESTONE SUIT may have been formed.

As a suitable illustration of this we may quote what Professor Phillips says regarding the "deposition of the oolitic system:"—

"The concretionary structure of these limestones is imitated in modern times only in situations where carbonate of lime is separated from chemical solution in water (Carlsbad). If we ascribe this origin to the oolitic sediment, the concretionary aggregation of the particles may be understood as arising from molecular attraction in the mass,

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* Attraction, Dr. Ure's Chemical Dictionary.

† See 36th Theorem and proofs.

and, in fact, many of the sphorules of oolite contain an internal nucleus of previously solidified matter, a small shell, a grain of sand, or somewhat else, capable of determining the condensation of the particles to particular centres; just as the matter of iron stone has collected into nodules round a fish scale, a piece of fern branch, or a shell."*

As there were no attendant circumstances in the *then* condition of our sphere to render what was applicable to one place inapplicable to another, the same causes would, of necessity, everywhere produce the same effects simultaneously, to encrust the bottom of the ocean in those localities which it pleased an omniscient Creator should be so prepared in perfect harmony with the development of His plans, and for the future benefit of His creatures.

We formerly explained at considerable length, that the researches which have been made into the state of the ancient fossil remains, reveal, in the most unequivocal manner, that there has been a succession of inferior animal life during those early geological epochs; and it was attempted to be proved, that as these successive generations were wholly dependant on the surrounding medium for their food, and matter for their coverings, each race must have become extinct when those peculiar substances, which it required, had been exhausted, by drainage, from the surrounding element. In the subject which has more immediately occupied our attention, we obtained a glimpse of some of the more prominent uses to which these testacea, conchifera, and zoophyta were made subservient by their agency during the course of their fixed and tranquil life. And we have now to endeavour to show, that by their death—which, for the cogent reasons already given, we assume as a matter of fact—they also contributed in a singular manner to the development of the great plan of Creation. With this view we shall first unfold the phenomena which attend the decomposition of animal matter.

"When," in the expressive language of Dr. Fleming, "the vital principle has deserted the body which it had constructed, and sur-

* Treatise on Geology, pp. 147, 148.

rendered it to the influence of the laws of inorganic matter, then, in obedience to the power of gravitation, the pliant twig hangs down, and the slender stem bends. In animals, the body falls to the ground; the pressure of the upper parts flattens those on which the others rest; the skin stretches; and the graceful rotundity of life is exchanged for the oblateness of death. The laws of chemistry then appear to operate in the production of the cadaverous smell, the prelude to putrefaction, when dust returns to dust."*

Messrs. Todd and Bowman confirm this, when they say—

"While these substances (those of animal bodies) retain a perfect organization, and are supplied with their proper stimuli, vital actions go on without interruption, and no change takes place in the matter of the organism excepting such as result from its proper affinities. But no sooner is the integrity of its structure destroyed, or the influence of the vital stimuli withdrawn, than action ceases, the organism dies, and the organic matter yields up its elements to form new compounds, a large proportion of which are inorganic."†

By the *hundred and thirty-ninth* Theorem it will be seen, "*That on the decomposition of animal substances taking place, when moisture and a certain degree of heat are present, putrefaction commences, the elements of the animal matter enter into new combinations, and generally pass off in the gaseous form; ammonia being always disengaged in considerable quantity: phosphuretted, sulphuretted, and carburetted hydrogen, and carbonic acid are likewise separated, and only an inconsiderable portion of earthy matter remains when the process is finished.*"

"When the putrefaction of animal substances commences," Dr. Murray states, "their elements enter into new combinations which generally pass off in a gaseous form; and only an inconsiderable quantity of earthy matter remains when the process is finished. A certain temperature is necessary to this process; below 32° it appears to be arrested, as is evinced by the bodies of the mammoth and rhinoceros found in ice blocks on the northern shores of Siberia, perfectly unaltered, though they must have lain there from a time

* Philos. of Zoology, vol. i. p. 39.

† Phisiol. and Anat. of Man, p. 15.

anterior to all history. The air does not seem essential to putrefactive changes by any chemical action, but a communication with the atmosphere is favourable, by allowing the elastic products to escape. The precise nature of these combinations has not, from the offensiveness of the process, been accurately observed, and they probably vary according to the nature of the animal matter, and the circumstances under which it is decomposed. *Ammonia*, formed by the union of the nitrogen and hydrogen of the animal matter, is always disengaged in considerable quantity. Phosphuretted hydrogen appears to be produced; and to this gas the odour termed putrid is chiefly owing. Sulphuretted hydrogen occasionally forms another part of the vapours disengaged from putrefying substances, as they have often in some degree its smell, and blacken the metals, a peculiar property of this gas. Carburetted hydrogen and carbonic acid are likewise separated, and it is probable that not only these binary combinations, but also compound gases, consisting of three or more of these elements, with oxygen, are formed and discharged.

"Putrefaction is the great process employed by nature to restore the elements of matter to simpler forms of existence, and to prepare them again to pass through new series of combinations. Being necessarily carried on at the surface of the earth, its products are diffused through the atmosphere, dissolved by water, and absorbed by the soil: they furnish the principal nutritious matter for the support of vegetables, and are thus again adapted to the nourishment of animals."*

"Like vegetables," says Mr. Reid, "animals, as soon as the vital principle has departed from them, are solely obedient to the laws of chemistry; they lose their form and entirely *disappear*, the elements of which they are composed enter into new states of combination, and they *decay or rot*, partly mixing with the air as transparent invisible gases, and partly crumbling down to powder, which, mixed with, cannot be distinguished from, the surrounding earth.

"From the presence of nitrogen, ammonia is formed during their putrefaction. *Ammonia* consists of hydrogen and nitrogen, as formed during the decomposition of animal substances; it is in union with carbonic acid in the state of *carbonate of ammonia*. Carburetted hydrogen, and small quantities of two other compounds of hydrogen, (sulpuretted hydrogen, and phosphuretted hydrogen gases) are formed during the decomposition of animal matters. The chief

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* Murray's Elements of Chemistry, vol. ii. pp. 676, 677.

products of the decomposition are water, carbonic acid, and carbonate of ammonia. . . . . . The bones and shells of animal bodies, on account of the earthy matter which they contain, endure for a very long period; but, gradually, as the animal matter or cement is decomposed, and separated from the earthy matter, also moulder away, and mix with the surrounding earth."*

"Ammonia," says Dr. Murray, "is always produced by indirect processes. Its ultimate source is usually from the decomposition of animal matter, of which its constituent principles are elements, and which, in the new combinations taking place in that decomposition, unite so as to form it."†

"In consequence," Dr. Fleming observes, "of this difference of composition, all vegetable matters may be easily distinguished when burning; the odour of each is so peculiar that the test may be safely employed by the most inexperienced. Besides, as vegetables abound in oxygen, they have a tendency, after death, to become acid by its new combinations with carbon and hydrogen; whereas the soft parts of animals, after death, are disposed to become alkaline, the azote entering into new combinations with the hydrogen, and forming *ammonia*."‡

"Organized bodies," say Messrs. Todd and Bowman, "are found in two states or conditions, life and death. . . . . . That of *death* is one in which all vital action has ceased, and to which the disintegration of the organized body succeeds as a natural consequence. . . .

"Such bodies are also capable of being resolved by chemical analyses into the inorganic simple elements, but comprising only about seventeen.

"Of the widely-spread elements oxygen, hydrogen, nitrogen, and carbon, two, *at least*, will be found in every organic compound; and these four, as Dr. Prout has suggested, may therefore be called the *essential* elements of organic matter. The other simple substances are found in smaller quantities, and are less extensively diffused; these may be termed its *incidental* elements. They are sulphur, phosphorus, chlorine, sodium, potassium, calcium, magnesium, silicon aluminum, iron, manganese, iodine, and bromine; the last two are obtained almost exclusively from marine plants and animals."§

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* Chemistry, by Hugo Reid, p. 181.

† Murray's Elements of Chemistry, vol. ii. p. 11.

‡ Philosophy of Zoology, vol. i. p. 41.

§ Physiology aud Anatomy of Man, pp. 4—6.

In order to preserve that continuity of thought, which is so essential in close reasoning, we have confined ourselves to a succinct account of the usual results of animal decomposition. One of the principal exhalations arising therefrom is *ammonia*, which originates in the combination of hydrogen with the nitrogen of animal secretion. But ammonia, introduced into a compound, in which the salts of alumina are held in solution, throws down their earthy base, even although acidulated with muriatic acid.* Consequently, as the decomposition of animal substances would assuredly cause ammonia, which is of low specific gravity, to ascend and enter in amongst the other ingredients in the compound solution held by the primitive ocean, so surely would its introduction precipitate alumina. Again, it is asserted by M. Berthollet, whose authority is of great weight in all matters relating to experimental chemistry, that "whenever an earth is precipitated from a saline combination by an alkali, it will carry down along with it a portion of its acid associate."† These truths we beg may be kept present to the mind, for we shall have occasion for them presently in the further illustration of this subject. It is also deserving of notice, as we have had occasion lately to remark, that the moderate doses of ammonia which would, from the nature of the circumstances, be introduced into the menstruum, would greatly aid the operations then going on.

Ammonia would exercise the same influence over whatever zirconia and glucina was held, at the time, in solution, for it also precipitates their earthy bases, and may account for the occasional presence of these scanty earths in the rocky masses of the globe; while

Barytes and strontites, in their several soluble states, aided the solubility of alumina; and they would, by the deposition of the latter, be left disengaged to act wherever their natural affinities thereafter induced them.

Barytes, strontites, and lime, by the attraction they exercise towards silex, would cause the latter to separate from its solution in potash;‡ and, according to the phenomena above-mentioned, to carry down a part of its associate; while a simulta-

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* Ure, p. 141, and Murray, p. 82. † Ure, p. 186. ‡ Murray, p. 111.

neous precipitating influence would be brought to bear on silex by ammonia depositing alumina. Alumina being no longer present to aid the acids in dissolving silex, that flinty earth would be discharged in a ratio proportioned to the deposition of the other; and these two concurring causes, the one positive, the other negative, will, to a certain extent, account for the simultaneous deposition of silex and alumina, two earthy substances which enter chiefly into the composition of all clays. But yet, it is evident, that these causes are by no means sufficient to account for the great preponderance which silica has in almost every formation, especially in the aluminous strata, whose principal ingredient it is. *Silica* being a substance so difficult of solution, and so recondite with respect to the agents capable of acting upon it, we are prone to suppose that some other causes beyond those stated were present in effecting its deposition; while, at the same time, we know that electrical currents would effect what we are otherwise at a loss to account for; and, as we do not doubt the existence of electrical currents, we naturally look to them as the efficient cause for the preponderance of the siliceous elements alluded to.

It has been shown that lime exercises a stronger affinity for carbonic acid than magnesia;* while both barytes and strontia possess stronger affinity than lime does, certainly to sulphuric, and perhaps to muriatic acid.† Carbonic acid enables water to hold carbonate of magnesia in solution. Alumina, by the affinity it exerts towards magnesia, aids its precipitation from saline compounds; and ammonia assists to precipitate magnesia from its solution.‡ Combining these truths we have the following:—1. That the abstraction of carbonic acid from the water would cause the precipitation of the carbonate of magnesia. 2. That the more powerful affinities of the other earths for the acids mentioned, by preventing this alkaline earth recombining with them, would tend to the same result. Lastly, that the free alumina in subsiding itself, by the affinity which it exerts to magnesia, would carry a part down along with it; the introduction of ammonia would effect

* Ure, p. 585. † Ibid, p. 184. ‡ Murray, p. 98.

the same results. In these combined causes we have a sufficient explanation for the presence of magnesia; while a varying intensity in the activity and quantity of the efficient causes, may, perhaps, be sufficient to explain the difference in the proportions observable in the several minerals of which this porous earth forms a part.*

It has been already shown how the metallic oxides are capable of being solved, and held in suspension by the primitive fluid; and it only remains now to explain the process by which they were precipitated from it. To do this we must have recourse to another of the principal binary compounds, which, according to the scientific writers formerly quoted, results from the decomposition of animal matter. We allude to phosphuretted hydrogen, which, in general *parlance*, precipitates metals from metallic solutions.† While confining these general assertions to particular cases, it can be said, that it throws down iron from the salts of that metal,‡ and also from that of manganese. Ammonia, likewise, precipitates iron, manganese, and other metals from their watery solutions.§ But all of these precipitates must yield the palm to the electrical influences acting in aqueous currents, which have been found to be peculiarly adapted, not only for crystallizing those and other metals, but also for disposing them in nodules, or small detached masses, for Mr. Fox justly observes, that "copper, tin, iron, and zinc, in combination with the sulphuric and muriatic acids, being very soluble in water, are in this state capable of conducting voltaic electricity."|| Iron, it would appear, is generally found as an oxide intermixed with argillaceous, calcareous, and siliceous earths.¶

Sulphuretted hydrogen, another of the binary compounds arising from animal decomposition, possesses the property, when in union with sulphur and the alkalies, of forming very variable triple combinations.** Carburetted hydrogen, which is the remaining exhalation, seems, under certain circum-

* Murray, pp. 82, 380. † Ure, p. 681. ‡ Murray, vol. ii. p. 210.
§ Literary Gazette for 7th May, 1836, p. 296. || Murray, pp. 380, 381.
¶ Murray, p. 197. ** Dr. Ure's Dictionary, p. 777.

stances, to deposit carbon, leaving the hydrogen free. It also possesses the peculiarity of impeding the union of oxygen and hydrogen, and other gases having an affinity for oxygen. When brought into contact with muriatic acid, it combines and produces an oily looking compound of considerable specific gravity. The respective bases of these two gases can be made to produce an interesting fluid compound, called carburet of sulphur,* which, when introduced together with potash and water, into metallic solutions, causes precipitates of a peculiar kind, called carbo-sulphurets.†

The remaining binary exhalation from the decomposition of animal substances after death, is carbonic acid. When we reflect how essential this is towards the growth and nourishment of the plants which were about to be brought into existence, we cannot but admire the wonderful wisdom and providential care of the Deity, who thus provided, beforehand, for every successive step in the work of creation.

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* Ure, p. 778.

† Ibid, p. 307.

SECTION IV.

DEPOSITION OF THE STRATA DURING THE NON-ROTATORY PERIOD.

CHAPTER XI.

The consequence of the introduction of any new element into chemical compounds of numerous ingredients. Evidences to show that clays, sandstones, and shales are composed of the same materials, which are assumed to have been held in solution by the primitive ocean. Chemical agency in the formation of the Old Red Sandstone. Geological evidence for the existence of extensive stratified masses of clays, sandstones, and shales underneath the Coal Measures. The succession of animal life during the period alluded to clearly deduced from the progressive change of the primitive ocean, and confirmed by the results of geological research. Wisdom of the arrangement which placed calcareous strata underneath the coal deposits, and between the latter and the igneous rocks which were ejected, amidst such intense heat, arising from the friction occasioned by the protorotation of the earth around its axis.

Before commencing the principal subject of this chapter, we beg to direct the attention, for a moment, to an important feature in all chemical compounds in which a variety of substances are held in combination. We allude to the change produced on the whole by the introduction of any new element. The greater affinity manifested by the introduced substance for some of the original elements causing these to abandon their former associates, in order to unite with it; and which, in turn, paves the way for other similar re-arrangements amongst the remaining ingredients, although no direct influence may, or indeed could, have been exercised over these latter by that which has been added to the compound. Changes such as we now refer to in the nature of the binary or ternary compounds, of which the mass consists, may have the effect of

altering the equilibrium of compatibility, and of producing such a state of incompatibility as may occasion the precipitation of whatever is requisite to restore the mass to a condition of equilibrium. For full information respecting substances which cause incompatibility, we beg to refer to the table given by Dr. A. Ure in his Chemical Dictionary, page 815, a perusal of which will convey a more perfect conception of what we desire, by this advertency, to impress on the mind.

It may, perhaps, tend to simplify the general question, were we to make it quite apparent, that the elements of the clays, sands, and shales which were formed during the period to which we now allude, correspond with the character of the precipitates supposed to have been discharged from the primitive fluid by the causes to which we have referred. This we shall best accomplish, perhaps, by giving the analysis of these several earths by writers who have treated the subject chemically.

"*Kaolin*, or *porcelain* earth," according to Dr. Ure, "consists of 52 per cent. of silica, 47 of alumina, and 0.33 of oxide of iron. *Potter's clay* contains 63 of silica, 16 of alumina, 1 of lime, 8 of iron, and 10 of water. Another analysis of the same gives 63.5 of silica, 33 of alumina, and 3.5 of lime. *Adhesive slate* consists of 62.5 silica, 9.5 alumina, 8.0 magnesia, 0.25 lime, 4.0 oxide of iron, and 14 water. *Common clay* 1.0 of silica, 31 of alumina, 0.5 lime, 21.5 sulphuric acid, and 45.0 water. *Clay slate* 48.6 of silica, 23.5 of alumina, 1.6 magnesia, 11.3 oxide of iron, 0.5 of manganese, 4.7 potash, 0.3 of carbon, 0.1 sulphur, and 7.6 of water."*

"Aluminite," says the same author, "consists of sulphuric acid 19.25, alumina 32.5, water 47.0, silica, lime, and oxide of iron 1.25."†

"The term clay," says Dr. Murray, "is ambiguous, but is applied to those earthy mixtures, more or less indurated, which imbibe water, and may be kneaded into a paste somewhat ductile. Alumina is the base of all of them, and gives this predominating character; it is mixed with various proportions of silex, magnesia, lime, and oxide of iron. Clay slate, as found by Kirwan, is composed of silex 38, alumina 26, magnesia 8, lime 14, and oxide of iron 14."‡

* Ure, pp. 331, 332.

† Ibid, p. 146.

‡ Murray's Elements, vol. ii. pp. 311, 312.

These results, it will be seen, very closely agree with what it was anticipated would take place, from the introduction of the peculiar exhalents of decomposing animal substances into a general menstruum holding alumina, silex, lime, magnesia, potash, soda, oxides of iron and manganese, and several acids in solution; we therefore consider it next to impossible for any unprejudiced mind to contemplate this perfect coincidence without feeling convinced, that strata corresponding to these characters would of necessity be the result. Indeed, we must either come at once to this conclusion, or for ever abandon all faith in the true meaning of words, or in the results of scientific experiments. After we have endeavoured to explain how some of the remaining earths were thrown down, we shall conclude the evidence, on these particular points, by proving, from the experience of geologists, that rocky masses of corresponding character do really exist precisely where, as the direct effects of these causes, they might most naturally have been sought for.

Although hitherto we have not alluded to the ocean having contained nitric acid; yet, as it held in solution the elements of which this is formed, viz., oxygen and nitrogen, it is perfectly legitimate to suppose that they *did* combine in such proportions as to form that powerful acid. It has been assumed that baryta and strontia were held in solution in the ocean, and assisted to cause the solubility of other substances; and, if they were so held in solution, they must have been in union with muriatic and nitric acids, in which states they alone present soluble compounds.

It will be remembered that we presented a list of the comparative affinities, given by Dr. Ure, of several substances with sulphuric acid, in which baryta predominated over all the others; strontia possessing properties and affinities very similar to the latter earth, we may conjecture that each of these would rob the other enumerated substances of their sulphuric acid. Again, baryta and strontia exercise very strong affinities for carbonic acid, and would, when both were free, combine with it. But baryta and strontia in union with the carbonic and sulphuric acids, form some of the most ponderous and less soluble of the earthy minerals; and,

consequently, they would, on assuming these combinations, be precipitated from the general menstruum. That such was actually the case, we consider will be sufficiently proved by the following quotations:—

" *Baryta*," says Dr. Ure, " is divided by Dr. Jameson into the four following species, viz. :—

" 1. *Rhomboidal Baryta, or Witherite.* A carbonate of baryta, with occasionally 1 per cent. of carbonate of strontia, and sulphate of baryta. It occurs in Cumberland and Durham, in lead veins which traverse a secondary limestone, and rest on the red sandstone; its specific gravity is 4.3.

" 2. *Prismatic Baryta, or Heavy Spar.* Of this there are nine subspecies. . . . They are all sulphates of baryta in composition. . . . Specific gravity 4.1 to 4.6. In Great Britain they occur in veins of different primitive and transition rocks, and in secondary limestones, &c., in the lead mines of Cumberland, Durham, and Westmoreland.

" 3. *Diprismatic Baryta, or Strontianite.* Its constituents are

" Strontia	61.20	69.5	62.0	74.0
Carbonic acid	30.30	30.0	30.0	25.5
Water	8.50	0.5	8.0	0.5
	100.00	100.0	100.0	100.0

" Its specific gravity is 3.7, and it occurs at Strontian, in Argyllshire, in veins that traverse gneiss, along with galena, heavy spar, and calcareous spar.

" 4. *Axifrangible Baryta, or Celestine* is a sulphate of strontia, with about 2 per cent. of sulphate of baryta. It occurs in trap tuff, in the Calton Hill at Edinburgh, and in the red sandstone at Inverness. It is abundant in the neighbourhood of Bristol. Specific gravity, 3.9."*

Besides these four species of baryta, in which there are occasional admixtures of strontia, these two earths unite together and form a mineral called *Barystrontianite* or *Stromnite*, of which Dr. Ure gives the following account:—

" It is composed of carbonate of strontia 68.6, sulphate of baryta 27.5, carbonate of lime 3.6, and oxide of iron 0.1, and is found in

* Ure's Chemical Dictionary, pp. 518, 519.

veins, or rather nests, accompanied by galena, at Stromness. Specific gravity 3.7."*

In continuation, the following passage from the "Old Red Sandstone," although somewhat long, yet is so interesting; indicates so clearly the difficulties of the case, and alludes to so many of the causes in operation during the deposition of the non-rotatory period, that we appeal to it with satisfaction, and are persuaded our readers will peruse it with pleasure:—

"The chemistry of the old red sandstone formation," says Mr. Miller, "seems scarcely inferior in interest to its zoology; but the chemist has still much to do for geology, and the processes are but imperfectly known. There is no field in which more laurels await the philosophical chemist than the geological one. I have said that all the calcareous nodules of the ichthyolite beds seem to have had originally their nucleus of organic matter. In nine cases out of ten the organism can be distinctly traced; and in the tenth there is almost always something to indicate where it lay—an elliptical patch of black, or an oblong spot, from which the prevailing colour of the stone has been discharged, and a lighter hue substituted. Is the reader acquainted with Mr. Pepy's accidental experiment, as related by Mr. Lyell, and recorded in the first volume of the *Geological Transactions?* It affords an interesting proof that animal matter in a state of putrefaction proves a powerful agent in the decomposition of mineral substances held in solution, and of their consequent precipitation. An earthern pitcher containing several quarts of sulphate of iron, had been suffered to remain undisturbed and unexamined in a corner of Mr. Pepy's laboratory for about a twelvemonth. Some luckless mice had, meanwhile, fallen into it, and been drowned; and when it at length came to be examined, an oily scum, and a yellow sulphureous powder, mixed with hairs were seen floating on the top, and the bones of the mice discovered lying at the bottom; and it was found that over the decaying bodies the mineral components of the fluid had been separated and precipitated in a dark-coloured sediment, consisting of grains of pyrites and of sulphur, of copperas in its green and crystalline form, and of black oxide of iron. The animal and mineral matters had mutually acted upon one another; and the metallic sulphate, deprived of its oxygen

* Dr. Ure's Chemical Dictionary, p. 200.

in the process, had thus cast down its ingredients. It would seem that over the putrefying bodies of the fish of the lower old red sandstone, the water had deposited, in like manner, the lime with which it was charged; and hence the calcareous nodules in which we find their remains enclosed.

"The form of the nodule almost invariably agrees with that of the ichthyolite within: it is a coffin in the ancient Egyptian style. Was the ichthyolite twisted half round in the contorted attitude of violent death? the nodule has also its twist. Did it retain its natural posture? the nodule presents the corresponding spindle form. Was it broken up and the outline destroyed? the nodule is flattened and shapeless. In almost every instance the form of the organism seems to have regulated that of the stone. We may trace in many of these concretionary masses the operations of three distinct principles, all of which must have been in activity at one and the same time. They are wrapped concentrically each round its organism; they split readily in the line of the enclosing stratum, and are marked by its alternating rectilinear bars of lighter and darker colour; and they are radiated from the centre to the circumference. Their concentric condition shows the chemical influences of the decaying animal matter; their fissile character and parallel layers of colour, indicate the general deposition which was taking place at the time; and their radiated structure testifies to that law of crystalline attraction, through which, by a wonderful masonry, the invisible, but well-cut atoms build up their cubes, their rhombs, their hexagons, and their pyramids, and are at once the architects and the materials of the structure which they rear.

"Another and very different chemical effect of organic matter may be remarked in the darker-coloured arenaceous deposits of the formation, and occasionally in the stratified clays and nodules of the ichthyolite bed. In a print-work the whole web is frequently thrown into the vat and dyed of one colour; but there afterwards comes a discharging process: some chemical mixture is dropped on the fabric; the dye disappears wherever the mixture touches; and in leaves, and sprigs, and patches, according to the printer's pattern, the cloth assumes its original white. Now, the coloured deposits of the old red sandstone have, in like manner, been subjected to a discharging process. The dye has disappeared in oblong or circular patches of various sizes, from the eighth of an inch to a foot in diameter; the original white has taken its place; and so thickly are these speckles grouped in some of the darker tinted beds that

the surfaces, where washed by the sea, present the appearance of sheets of calico.

"The discharging agent was organic matter; the uncoloured patches are not mere surface films, for, when cut at right angles, their depth is found to correspond with their breadth, the circle is a sphere, the ellipsis forms the section of an egg-shaped body, and in the centre of each we generally find traces of the organism in whose decay it originated. I have repeatedly found single scales in the ichthyolite beds surrounded by uncoloured spheres about the size of musket bullets.

"It is well for the young geologist carefully to mark such appearances—to trace them through the various instances in which the organism may be recognised and identified with those in which its last vestiges have disappeared. They are the hatchments of the geological world, and indicate that life once existed where all other record of it has perished."*

To complete the evidence on this particular branch of our argument, it is now only necessary to bring forward the promised proofs, that aluminous and arinaceous beds and shales intervene between the carboniferous part of the coal measures and the limestone beneath. For this purpose, besides begging reference to the incidental evidence in what has been already quoted from the works of Sir Henry de la Beche, Dr. M'Culloch, and others, when establishing the position and character of the carboniferous limestone, we have to add the following extracts bearing more immediately on the present question:—

"With respect to the carboniferous group," says M. de la Beche, "the masses of the old red sandstone, carboniferous limestone, and coal measures are well separated from each other, though there may be small alternations at their contact."†

And again, quoting from Professor Sedgwick, he says—

"On the re-appearance of the carboniferous limestone at the base of the Yorkshire chain, we still find the same general analogies of structure—enormous masses of limestone form the lowest part, and the rich coal fields the highest part of the series; and we also find

* Old Red Sandstone, pp. 288—292.

† Manual of Geology, p. 431.

the millstone grit occupying an intermediate position. The millstone grit, however, becomes a very complex deposit, with several subordinate beds of coal; and is separated from the great inferior calcareous groups, not merely by the great shale and shale limestone, as in Derbyshire, but by a still more complex deposit, in some places not less than 1,000 feet thick, in which five groups of limestone strata, extraordinary for their perfect continuity and unvarying thickness, alternate with great masses of sandstone and shale, containing innumerable impressions of coal plants, and three or four thin seams of good coal, extensively worked for domestic use. . . . . The alternating beds of sandstone and shale expand more and more as we advance towards the north, at the expence of all the carboniferous groups, which gradually thin off, and cease to produce any impress on the features of the country.*

"According to M. de Villeneuve, the coal measures and limestone strata alternate at their contact with each other between Liege and Chaude Fontaine. The limestones are metalliferous, bluish, and compact, and contain subordinate conglomerates of blue limestone. . . . . . The upper part of the limestone and sandstone contain aluminous shale, worked for profitable purposes.

"According to the same author, the coal measures, which are composed of the usual mixtures of sandstones, shales, and coal beds, present at the Montagne de St. Gilles, no less than 61 beds of the latter. . . . . The coal beds of Liege contain 83 beds of coal.†

"M. Pusch describes the coal measures in Poland as extending from Hultschin to Krzeszowice. . . . . A black marble employed in the arts supports the coal measures. M. Pusch considers this marble as equivalent to the carboniferous limestone of the English geologists, and observes that the calcareous conglomerates which accompany the coal sandstones and shales in the gorges of Miekina and Filipowice are referable to the same marble beds."‡

And in conclusion from this author—

"After a thickness of seven or eight hundred feet of calcareous rock had been formed, another great change in the matter deposited was effected; not, however, so suddenly but that the arenaceous sediment which afterwards became so abundant, and the calcareous

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* Manual of Geology, pp. 431, 432, taken from Professor Sedgwick's Address to the Geological Society, 1831.

† Manual, p. 436.

‡ Ibid, p. 437.

matter, were alternately produced for a comparatively limited period. An immense mass of sandstones, shales, and coal was then accumulated in beds, one above another, which, though very irregular with regard to the relative periods of deposit, are frequently persisted over considerable areas.

"By general consent the coal is considered as resulting from the distribution of a body of vegetable remains over areas of greater or less extent, upon a previously deposited surface of sand, argillaceous silt, or mud, but principally the latter, now compressed into shale."*

"The term shale," says Dr. M'Culloch, "includes all the secondary and tertiary argillaceous schists. . . . . Its varieties are enumerated in the classification of rocks; and I need only remark here, that it is more or less indurated, and that its prevailing colours range from grey to black, but comprise also red and yellow hues of considerable variety. When highly ferruginous, it passes into argillaceous ironstone; and on becoming calcareous, into schistose marl, and into limestone.

"In this case in particular, or when interstratified with limestone, it is the frequent seat of fossil shells; while the argillaceous beds of such a series often contain a greater proportion of these than the calcareous rock. In the coal series it often contains bitumen, carbonaceous matter, or both; and, in the same circumstances, is the frequent repository of vegetable remains. . . . . .

"Some varieties of shale, like others of primary argillaceous schist, contain a decomposable pyrite; being therefore wrought for alum, under the name of aluminous slate.†

"It must have been already understood," continues the same author, "from former observations, that the coal series is not anywhere found among the secondary strata, however steady its place may be where it exists; but that it occurs in distinct tracts often widely separated from each other. These are known, technically, by the term coal fields, and they vary in their characters in different places; not only in their extent and in their depth, but in the order of succession of the integrant rocky strata, in the numbers and relative proportions of these; and in the numbers, thickness, succession, and qualities of the beds of coal. . . . . The strata which

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* Manual, p. 441. *Shale*, according to Mr. Lyell, is "a provincial term adopted in geological science to impress an indurated slaty clay." Vol. iii. glossary.

† Geology, by Dr. M'Culloch, vol. ii. pp. 248, 249.

accompany the beds of coal, contributing to form what is here called the series, consist of sandstones, shales, limestones, and clays. . . . . The characters of the sandstone vary, being in some places a conglomerate, but more frequently fine, when it is sometimes compact, pure, white, at others micaceous, or argillaceous, or ferruginous and tender, occasionally also containing pyrites, and often blackened by carbonaceous matter, or else including distinct fragments of charcoal. . . . . .

"The shales vary much in aspect and hardness, passing at length into clays equally various, and sometimes containing bitumen, carbonaceous matter, and vegetable fragments. In this class imbedded nodules, or distinct strata of argillaceous ironstone often occur, and in conspicuous quantities, forming the principal supply of ore for the iron foundries."*

"The most remarkable accumulations of coal," says Professor Buckland, "in England are in the Wolverhampton and Dudley coalfield, where there is a bed of coal ten yards in thickness. The Scotch coalfield, near Paisley, presents ten beds whose united thickness is one hundred feet. And the South Welsh coal basin contains, near Pontypool, twenty-three beds of coal, amounting together to ninety-three feet.

"In many coalfields the occurrence of rich beds of iron ore in the strata of slaty clay that alternate with the beds of coal, has rendered the adjacent districts remarkable as the site of most important iron foundries; and these localities, as we have before stated, usually present a further practical advantage, in having beneath the coal and iron ore a substratum of limestone that supplies the third material required as a flux to reduce this ore to a metallic state."†

Concurring testimony to the same effect is borne by Messrs. Lindley and Hutton, although they had occasion to advert to the circumstances only incidentally, when describing the fossil flora of the coal formations:—

"The beds usually denominated the coal measures" (say they in part 1st of vol. ii. pp. vi. and vii.), "being the higher part of the carboniferous formation, repose upon, and are conformable to, the inferior members of the series.

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* Geology, by Dr. M'Culloch, vol. ii. pp. 301—303.

† Bridgewater Treatise, vol. ii. p. 529.

"They consist of irregularly alternating beds of sandstone, shale, or argillaceous schist and coal, whose aggregate thickness (in Northumberland and Durham), may be estimated at about three hundred fathoms. This may not probably be correct, but is near enough to the truth for our purpose."

The following evidence, given by MM. Prestwich and Murchison before the Geological Society, is interestingly corroborative of these alterations in the coalfields:—

"Mr. Prestwich," say the editors of the Literary Gazette, "commences his account of the formations by describing the lower silurian rocks. These deposits constitute a narrow belt of highly inclined strata around the Wrekin and Arcol hills, and are composed in the lower part of a friable, coarsely-grained, quartoze grit, and in the upper of micaceous flags. The Caradoc sandstones are next described; and afterwards the Wenlock shale and limestone, the Ludlow rocks, the old red sandstone, and the carboniferous limestone; and finally, the coal measures. These are formed of the usual alternations of shale, sandstone, and coal; and in those portions of the district where they are most fully developed, have been ascertained to consist of 135 beds, making a total thickness of about 250 yards. The colour of the first 70 or 80 beds, commencing at the top, is light grey, yellow, or red; that of the next twenty is very dark, or nearly black; and that of the underlying strata is light. These distinctions prevail generally, but not universally. In the upper part of the series clays and soft calcareous sandstone predominate; in the middle argillaceous sandstones and clays; and in the lower hard fine-grained sandstones, occasionally micaceous. The beds of coal in the upper division of the series are widely separated, and extremely irregular; but in the lower they are thick, nearer together, and are persistent throughout the whole field. At some of the pits the beds vary greatly in number and thickness, in consequence of the thinning out of some, and the interpolation of others; and the memoir contains a valuable series of sectional lists obtained from the ground bailifs.

"Next in importance to the beds of coal are the layers of argillaceous carbonate of iron. This valuable ore generally occurs in flattened nodules constituting regular seams, which are distinguished by the names of penny-stone, the chance-stone, the ball-stone, the ragged-robins, &c. &c. Some of these layers extend throughout the field, but others are of local occurrence; and the aggregate number

in a pit varies from two to seven. They are generally imbedded in shale, but occasionally in sandstone. In some parts of the district, and situate near to the top of the series, is a bed of freshwater limestone. The petroleum, or tar spring, for which Colebrook Dale has been so long celebrated, issues from a thick bed of sandstone in the upper part of the coal measures. . . . . . Titanium has been produced in considerable abundance in the iron furnaces."*

No further evidences, we presume, need be given to prove the existence of extensive stratified formations, consisting of clay, sandstone, and shale, associated with the carboniferous limestone, and generally underlying the coal measures.

The calcareous deposits, it has been shown, owe their origin, in a great degree, to the exuviæ of innumerable testaceous and conchiferous mollusca and zoophyta, and to the chemical decomposition occasioned by their death, whereby they promoted the deposition, from the surrounding water, of those aluminous, arenaceous, and shaly strata which are intermixed with, and found covering, their fossilized remains; electrical influences having been also employed as a slow but certain and universal agent to co-operate with these other causes, and to complete the deposits in question.

At this juncture we have, again, to allude to the irresistible inclination which water, impregnated with various elements, has to assume a state of chemical equilibrium whenever the disturbing causes have ceased to exercise their influence over the mass; or, in other words, whenever the chemical affinities of the several ingredients become stronger than the disturbing influence.† Now, there is scarcely any fact in geology better authenticated than that during the entire course of the older formations, there was a succession of inferior animal life differing from the present generations in proportion as their remains are distant from the surface.‡

This, therefore, having been the case, it is natural to conclude, that each race, as it approached extinction, would ex-

* Literary Gazette, 16th April, 1836, pp. 248, 249.

† 69th Theorem, and proofs.

‡ 16th and 133rd Theorems, and their proofs.

ercise a diminished influence on the surrounding medium, until at length it reached a point when it would be altogether nihil.

We feel persuaded that the subject which has more especially occupied our attention in the preceding observations is one which has not been sufficiently dwelt upon by others, nor has it attracted that attention which it ought. We are disposed to think, that if properly considered, it may assist in part to clear up the mystery which hitherto has enveloped the operations of those long by-gone times. The fact of there having been a succession of races of inferior animal life throughout the stratiferous period of the ancient ocean, combined with the assurance, acquired by the registered accumulations of their fossilized remains, "that there is not one solitary example on record of a race or species which had become extinct ever having been thereafter recreated,"* when contrasted with the *permanency* of the recent allied tribes of inferior animal life in our *present seas*, seem to afford us a clear glimpse of the operations which were then going on, and the changes which were taking place underneath the dark, and otherwise incomprehensible primitive water.

For, although the more rigorous proof of analysis at any of these periods of important change be now out of the question, yet, in these stereotyped vestiges, we possess a method of determining the mutations of the scene in a way scarcely less certain. The ever-changing, mingling fluid has come down to us in its purified state, bringing no evidences in itself of what it once was, but it has clearly recorded the progressive stages through which it has passed by the indelible legends written and left behind it in stony concretions, the former habitations of its living associates, as it passed onward and onwards to its present limpid condition. While those endurable records, if properly studied and applied, may be found of essential benefit in guiding us through the maze which lies before us. We sometimes find that striking contrasts, by arousing the attention, become useful in such mental exercises; and none can be more so, perhaps, than that which is afforded by the *static* condition of the water of the actual ocean and the permanency

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* Ancient World, Ansted, p. 56.

and persistency of its inhabitants, when put into juxta-position with the *mutation,* so well authenticated, which took place in the living forms of ancient times and a progressively purifying medium. A continuous *change* in the character of marine animal life, with the *static* condition of our "seas," is not more imaginable than is a *static* condition of the primitive fluid with the *mutability* of its living inhabitants! Judging by the laws which govern materialism, we can neither consistently imagine the one combination nor the other!

But in addition to the legends which the ancient ocean has bequeathed to us by means of the fossilized remains of its inhabitants, we are happily furnished with a series of threads of the slenderest and most even description, which, throughout the whole of this shoreless and atmosphereless water, have passed up with unbroken continuity from the earliest dawn of animal life to the latest geological formation; we allude to the calcareous formations. *Lime*, wherever it has been taken for analysis, has been found to be identically the same.* And this holds good whether that which is examined be derived from the nethermost series of rocks, or from the coral islands of our present seas. Now, without stopping at present to enquire whether *calcium* itself be peculiarly an animal *secretion,* but proceeding on the general admission that *lime* is an animal *product,* and presuming its production to have been one of the designs of the Creator during the stratiferous period of the primitive ocean, and even to the present day, and taking into consideration that a substance which, from its first appearance on earth to the last particle yet formed in the sunny seas of the enter-tropical regions, was destined to be invariable, although produced by successive and distinct races of marine animals, we have no other alternative but to conclude, that to continue the unvarying nature of the animal product, *lime,* it became requisite to adapt the form and construction, and consequently the physiological powers of the elaborators, to the menstruum from which they extracted it as it changed from stage to stage. We can testify, by analysis, that the *product* has ever been the same. We are as equally well assured that the fabricators

* 16th Theorem, section F.

have been on successive occasions *changed;* a combination of these two terms can leave no doubt upon the mind, that the menstruum, from which the latter derived the elements of the former, was likewise undergoing a corresponding change.

That the deposition here referred to, and which was so essential should, however, be continued, new races of animals adapted to the altered medium, and capable of deriving sustenance from it, would no doubt be willed successively into existence; while the fate which awaited their predecessors would, in time, also overtake them. Consequently, what has been said of any one generation of inferior animal life may, with equal justice, be applied to all the others, while it likewise points out that the primitive water would, in all probability, eventually assume such a condition as that animal secretion, alone, could not drain it of those peculiar elements, which the ulterior plans of the Creator required that it should part with; and, therefore, it might have been conducive to employ the influence of vegetable life to assist in carrying on the process of purifying the ocean, and to cause to be deposited, at its base, masses of carboniferous material which vegetable secretion, alone, could supply.

Geology seems to corroborate, very fully, this view of the case; for we are shown, as the result of its researches, that not only were there new races of shelly animals brought into existence about that period, but plants likewise. For this very important modification in the plans of the Creator, due preparation seems to have been made. One of the tendencies of the chemical composition and decomposition which had been going on in the primeval water was to impregnate the menstruum with the element of carbon, the main ingredient in the construction of woody fibre. We deem ourselves, therefore, authorised to consider this to have been the epoch when it pleased the Creator to bring to perfection the submarine vegetation whose accumulated remains were providentally destined to furnish, in after ages, to an entirely distinct race of beings that which, in time, would be as essential for *their* use and comfort as what was held in chemical suspension had been for the growth of those plants which elaborated the carboniferous portion of the coal measures.

Considering that we can, with so much certainty, trace back the formation of the great coal deposits to the earlier ages of the creation, and are thereby constrained to acknowledge the goodness and manifest design of Providence in heaping up those vast subterraneous stores which contribute alike to the power and to the comfort of man, we feel assured that we ought not to doubt, for one moment, of its having been the same beneficent hand which, with equal priority, provided for the requirements of those inferior beings which he saw fit in his goodness, and found necessary by his wisdom, to will into existence, when *their* peculiar agency was required to work out his sovereign pleasure, during *their* day and generation. We are thoroughly persuaded ourselves, and would, most willingly persuade others, that the confidence arising from experience in our day ought to be applied by analogy, with unfaltering alacrity, to the case of all those inferior races of plants and animals, whose existence is known to us now only by their fossilized remains.

The manner in which they were collocated on the earth's submarine surface teaches us, also, that everything was done with consummate wisdom ; for it is in perfect accordance with the known habits of plants and fixed animals (without at present taking into account other apulmonic inhabitants of the water), to increase by radiating from centres or foci.* Placed, as they no doubt were, at appointed and proportional distances, they would at length, by gradually extending their respective areas, intermingle along their borders of demarcation, and fulfil the object of their original collocation towards the ultimate end in view, namely, that of producing a variegated whole, fitly jointed together and well adapted for preparing strata, capable of being applied to what was designed, with a view to the great revolution which was to take place when the earth should be caused to rotate around its axis. Thus every successive stage in the work of creation affords convincing evidence of the most consummate wisdom and benificent foresight having been exercised in preparation for it.

By what has preceded, we perceive distinctly the adaptation

* Principles of Geology, by Mr. Lyell, vol. ii. p. 131, et sequitur.

of the means to the end, whose accomplishment has been revealed to us by the researches of geologists into the external crust of the earth; in some localities there having been discovered, the remains of wide and extended colonies of shell fish alternating with those of broad patches of vegetation; and in other parts, symptoms of both having partially intermingled.

The idea of successive creations of animated beings previous to the general one, narrated in Genesis by the inspired historian, may appear to some to be heterodox. It is not our desire, as we have said before, to insist on any one agreeing with us in those points of belief; yet it is due to all to explain, that as we are most firmly convinced that everything which is, was created by God, we can have no just grounds, considering we believe in the later or ultimate acts of his creative energy, to withhold our belief as regards those instances of greater antiquity. Besides, if the successive tribes of plants and testaceous animals so often alluded to were *not* created in succession during the period of non-rotation, *they were not created at all,* for no *direct* mention is made of them in the narrative given in Genesis; their *previous* creation being deducible only by inferences arising out of the differential mode of reasoning which has been applied to that part of Scripture. But as, in confirmation thereof, geology reveals their existence, and sound reasoning leads us to imply their uses, no motive remains for our withholding assent to the only deduction which can, legitimately, be drawn from the facts of the question, and from the unlimited powers of God, the Creator, namely, *that there were several successive creations of both animals and plants, during a long but indefinite period in the earlier geological history of the earth.*

In addition to the direct proofs in favour of the inference which we have just come to on this point, the consideration, that layer after layer of inert matter was accumulated upon each other until they attained an immense aggregate thickness, precludes us from conceiving, with propriety, that any *one creation* of animals* or plants could have surmounted

* Even the polypiferous creatures which have been most persistent through-

these accumulations, and have survived throughout their whole duration; it being quite at variance with sound analogy to suppose that the spawn of testacea and zoophyta, or the sporules of acotyledonous plants could have done this, even could these animals and plants have derived sustenance from the surrounding medium which was itself continually changing by the effects of their own drainage, and by those of chemical affinity. On the contrary, they must each eventually have been, as they really were, buried under the effects of these joint causes; and, finally, in consequence of the change produced on the elements of the primeval ocean, a corresponding change was essentially necessary in the adaptation of its animal and vegetable inhabitants, in order that the process of purification should be continued.

When we take a general view of the works of the Creator; and when, with more speciality, we restrict our attention to the construction of the complex and finished piece of mechanism of the human frame, and behold its numerous muscles, each wrapped in its own ponobrotic envelope, meeting, and even overlapping, in order that they should, in their several departments, perform the work assigned them, and conjointly constituting an harmonious whole, well adapted for the end intended, we should have no hesitation in supposing that similar forethought and design were applied to the collocation of the strata, and to the formation of the great body of the earth. It is true, the objects are imcomparably dissimilar in size; yet the gigantic parts of the earth will be found to be in as perfect proportion as those of the human frame; and were we more narrowly to trace the special design of each, we would, no doubt, discover equal wisdom and intention pervading them both. We would find that as the ponobrotic coverings are useful to the muscles in protecting them from the effects of friction, *inter se*, so the *limestone* and *shaly formations* rendered a similar service to the coal measures, when the first rotation of the earth caused the development of so much heat

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out the whole geological era, seem, from their productions of earlier times, to have been distinct in some respects from those which now inhabit the ocean.—Ancient World, p. 32.

as would, without these impervious barriers, have fused and rendered those immense store depôts of fuel utterly unserviceable. And we shall, at last, be convinced that the same Almighty hand—which fashioned the earthy mould of our first progenitor into bones, muscles, ligaments, and manifold winding conduits, and filled them with fluids ere yet these last had circulated or beat a single pulsation—did, with the same consummate wisdom and forethought, lay down every distinct bed of calcareous, carboniferous, or aluminous strata, in ready preparation for that eventful moment, seen by himself from all eternity, when, by the formation of light, the dark, motionless orb was caused to start into its description of life, and to rotate in the gladdening rays of a sun, which was to be illumined almost immediately thereafter, as the inexhaustible reservoir of its light and heat, and the teller of its signs, its seasons, days, and years.

SECTION IV.

DEPOSITION OF THE STRATA DURING THE NON-ROTATORY PERIOD.

CHAPTER XII.

Prefatory observations respecting the universal warmth which prevailed in the water of the non-rotating sphere. Chemical action the principal secondary agency employed in producing that result. Effects of animal and vegetable vitality again alluded to. The consequences arising also from the death and decomposition of animals and plants particularly investigated with reference to the purification of the ancient ocean; more especially the effects of ammoniacal exhalations arising from the putrefaction of animal remains. Geological data, and actual results adduced in corroboration. The "blending" and the "thinning out" of the strata attempted to be accounted for by the Dynamical Theory. And, in conclusion, an endeavour to explain, according to the same principles, by what means the primitive ocean changed its character from turbid, fresh water, to the saline and pellucid seas of the present period.

We have already alluded to the ample provision which was made for the nourishment of the vegetable kingdom of this early period, by the suffusion into the water of carbonic acid arising from the decomposition of animal matter; and reverting now to the warmth, so often already alluded to, which prevailed throughout the water during the formation of the great coal measures, although these were accumulated before the light was willed into existence, we shall, with becoming deference, endeavour to trace the source of this increased temperature. It would, assuredly, be an unwarrantable use of the reasoning faculties conferred on finite beings, to attempt to raise any veil which has been purposely cast

over his works by the common Creator, or to dogmatise on points of such entity as whether *economy in time* be an object of importance to a Being who inhabits eternity. Yet, a minute investigation into his other works reveals a principle of the most rigid economy running through the whole—in the *weighing* of every atom, and in the *measuring* of every drop of fluid; and we may, therefore, consider ourselves authorized, without being accused of temerity, to conclude that the same principle has been exercised in *duration* also. This we are more particularly warranted to do, as it unfolds another adorable feature in the attributes of the Omnipotent. It would appear that, while economy in time was studied in the plan of the Creation, while his infinite wisdom induced God to create the particular tribes of animals and plants alone capable of fulfilling his designs at that period; his justice induced him to respect the nature which he conferred on each, and his goodness to care for their well-being—the well-being even of the most subordinate of his creatures. They were carefully nurtured, and every thing, consistent with their several natures, was done to enable them to assume the fullest expansion of which they were respectively susceptible. Warmth very essentially contributed to effect this, and warmth was conferred upon them. Its existence, *by inferences drawn from the gigantic relative size of the organic remains*, has already been demonstrated in a previous chapter. We shall, therefore, in this, while we allude with reverence to the ultimate source, proceed to trace the secondary agency employed in its development. To do this let us, first of all, have reference to the *forty-ninth* Theorem, viz:—"*That it may be assumed, as a general principle, that chemical combination is one of the numerous causes by which heat may be developed or absorbed; while caloric, or heat, is itself the most general agent employed in all chemical operations;*" and, in continuation, peruse briefly some of the authorities which support this conclusion.

"One of the chief agents in chemistry," says Sir John Herschell, "on whose proper application and management the success of a great number of its enquiries depends, and many of whose most

important laws are disclosed to us by phenomena of a chemical nature, is *heat.*

"The most obvious sources of heat are the sun, fire, animal life, fermentations and violent chemical actions of all kinds, friction, percussion, lightning, or the electric discharge, in whatever manner produced, the sudden condensation of air, and others so numerous and so varied as to show the extensive and important part it has to perform in the economy of nature. The discoveries of chemists, however, have referred most of these to the general head of chemical combination. Thus, fire, or the combustion of inflammable bodies, is nothing more than a violent chemical action attending the combination of their ingredients with the oxygen of the air. Animal heat is, in like manner, referable to a process bearing no remote analogy to a slow combustion, by which a portion of *carbon*, an inflammable principle existing in the blood, is united with the oxygen of the air in respiration, and thus carried off from the system; fermentation is nothing more than a decomposition of chemical elements loosely united, and their re-union in a more permanent state of combination, &c."*

"It may be taken," says a writer in the Cabinet Cyclopædia, "as a general principle, that chemical combination is one of the numerous causes by which heat may be developed or absorbed. Every part of chemical science abounds in facts illustrative of this principle."†

"Combustion," writes Dr. Ure, "is the disengagement of heat and light which accompanies chemical combination. . . . . . Whenever the chemical forces which determine either composition or decomposition are energetically exercised, the phenomena of combustion or incandescence, with a change of properties, is displayed. The distinction between supporters of combustion and combustibles, on which some late systems are arranged, is frivolous and partial. For, in both cases the heat and light depend on the same cause, and merely indicate the energy and rapidity with which reciprocal attractions are exerted. Thus, sulphuretted hydrogen is a combustible with oxygen and chlorine; a supporter with potassium, &c. &c.

"From the preceding facts it is evident that no peculiar substance or form of matter is necessary for producing the effect (evolution of

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* Natural Philosophy, Cab. Cyc. pp. 310—313.

† Dr. Lardner on Heat, Cab. Cyc. p. 354.

heat); but it is a *general* result of the actions of any substances possessed of strong chemical attractions, or different electrical relations, and that it takes place in all cases in which an intense and violent motion can be conceived to be communicated to the corpuscles of bodies.

"Finally, we may establish it as an axiom, *that combustion is not the great phenomenon of chemical nature, but an adventitious accidental accessory to chemical combination or decomposition; that is, to the internal motions of the particular bodies, tending to arrange them in a new chemical constitution.*"*

Before concluding this branch of evidence, it may not, perhaps, be superfluous to notice that there are certain substances which evolve great degrees of heat on combining with others. The acids, in general, on combining with water evolve heat.† Azote and phosphorus combine at common temperatures, and produce heat without light.‡ Iodine also produces combustion in uniting with azote and other substances by the intensity of their mutual action. And as this peculiarly energetic substance has been discovered in most of the fuci, and several of the other algæ,§ there can be no doubt of its presence and, consequently, of its effects. That the circulation of voltaic electricity is accompanied by a continued development of heat, lasting as long as the circuit is complete.|| And, lastly, "That water has a greater capacity for caloric than an equal bulk of any solid substance known."¶

After what has been so recently said, it may scarcely be requisite to reiterate, that the warmth which existed during the incipient stage of creation, and with which we have just been occupied, could not have been occasioned by the sun's rays; for that orb was not yet illumined; neither was it the effect of radiation from masses of heated mineral matter, for the hills and continental ranges had not been moved from their original horizontal position, had undergone no friction, consequently were not imbued with any superabundant heat, which,

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* Chemical Dictionary, pp. 353, 354, 368. † Ure, p. 5. ‡ Ibid, p. 540.
§ Ure, p. 537. || Connexion of the Sciences, p. 306—312.
¶ Hutchison's Essay on Unexplained Phenomena, pp. 25, 26.

by requiring to part with, they would have communicated to the surrounding media; and, therefore, we are shut up to the necessity of considering, that the secondary agency of the heat or warmth in question *was electrical currents and chemical combination and decomposition.* But "heat occasioned by chemical action is derived," as has just been shown, "from motion amongst the corpuscles of elementary bodies, while its rate is determined by the rate of that intermotion." And as, on the other hand, we are equally well assured "that matter can neither produce in itself spontaneous action, either from a state of rest to that of motion, or diminish any motion it may have received from an external cause, or change its direction;" we are, ultimately, obliged to confess, that whatever may have been the nature of the intermediate agency, or the instruments employed to occasion the intermolecular motion engendering that warmth, which all geologists agree in considering did exist throughout the primitive ocean, *its ultimate cause was not, could not, have been material.* We must look to what is beyond matter, to a higher source, and to a distinct set of evidences—evidences which, for our assurance and satisfaction, are plainly and unequivocally set before us.

As our present argument, however, admits of being conducted with reference more directly to the material and secondary agency employed, we shall, therefore, proceed by that line of approach.

The warmth in question having proximately been engendered by chemical and electrical action, it follows that its maximum would be wherever these were in greatest activity. This was at the bottom of the ocean, throughout its whole extent; where myriads on myriads of animals and plants were incessantly at work imbibing the materials chemically suffused in the water, and elaborating them into the substances of which their bodies and their coverings were composed. There also the lower stratum of water, by being despoiled of its earthy associates, and impregnated with ammoniacal gases, by exhalations from decomposing animal matter, would, in addition to the extent of volume, acquire a reduced specific gravity, and be made to ascend, to give place to colder and less pure

portions, to be in their turn freed from their earthy load, and to be expanded by warmth; and thus a constant and equalizing current would be kept up between the lower and the upper surfaces of the great mass of water constituting the primeval ocean. The peculiar adaptation of this alternation, which caused the earth-charged portion to descend and deposit its load within reach of those apulmonic beings which required the supply, and would, otherwise, have been deprived of it; and, on the other hand, which raised whatever of the ammoniacally impregnated portion escaped recombination with suffused bases to the surface, for purposes of future usefulness, denotes the same provident forethought so strongly illustrative of the whole proceedings of the Creator; and fills the mind with admiration and thanksgiving. While it should not be forgotten that the material crust of the Earth, whose construction was partly accomplished by these, though it could not thereby have acquired a *heat* approaching in any degree to fusion, would become a regulating reservoir of a considerable residue of that warmth which was thus constantly evolving itself along the whole extent of its submarine surface; and whose accumulation in the water was much assisted by the great capacity of this for caloric and by its atmosphereless condition; the whole having been, as it were, conducted in vacuum.

The mind being sufficiently prepared, by the review laid before it of the adaptation of the material part of the Creation during the period to which we allude, to the species of animal and vegetable life then willed by the Omnipotent into existence, it becomes requisite to enquire next what would be the probable results, according to natural causes, of their growth and propagation, and, afterwards, of their decay and death. We have little to add, to what has already been brought forward, respecting the agency of the animal kingdom in the composition of the solid strata. During their lifetime they secreted calcareous coverings, whose remains have contributed very considerably to the formation of the limestone series. After death the elementary components of their fleshy parts appear to have entered into a new series of binary and ternary compounds, which—in seeking the level that their reduced specific gravity induced them to do—disturbed the chemical

equilibrium of the water through which they ascended, and assisted to cause the precipitation of aluminous, calcareous, arenaceous, and other deposits, which partly intermingled with, and partly covered, their endurable remains.

The services which were performed by living plants in secreting and accumulating carbonaceous matter in their own gigantic forms, and by instilling certain deposits into the strata by exudation from their roots, have been fully explained in the chapters which were dedicated to the primeval vegetable kingdom. Consequently, at present, we have merely to enquire into the probable effects likely to have occurred by the decomposition of vegetable substances—in as far as they differ from those produced by animal decomposition—when introduced, by exhalation, into the surrounding fluid; also the disturbance they were capable of occasioning in its chemical equilibrium; and the effect which animal and vegetable exhalations would have on each other when intermingled by the luni-solar current; and the new compounds they would form, and precipitates which they would throw down.

To accomplish the former of these objects we shall, first, recapitulate the *hundred and twenty-eighth* Theorem, which states, "*that when the principle of life has departed from vegetable substances exposed to the atmosphere, they begin spontaneously to decompose, and their remains, entering into new combinations, form carbonic acid, water, carbonic oxide, and carburetted hydrogen; these modifications continuing until nothing remains but the saline, earthy, and metallic substances originally contained in the vegetable matter. But when the exclusion of the atmosphere, and considerable pressure take place, the former circumstance removing the agency of oxygen, and the latter preventing the formation of elastic products, the decomposition does not proceed beyond the accumulation of a carbonaceous residium; from which it is probable have been derived the several varieties of bitumen and coal;*" and as these results may exercise considerable influence over our future reasoning, we shall strengthen their impression by a few concise and apposite quotations:—

"All vegetables," says Mr. Reid, "when the principle of life has

departed from them, begin spontaneously to be decomposed. Their elements have a tendency to separate from each other, and form new compounds very different from those which compose the living plant. These are carbonic acid, water, carbonic oxide, and carburetted hydrogen. The two former are the chief results of the decomposition, the two latter are formed more sparingly, and principally when there is not a free supply of oxygen. . . . . . In vegetables which decay under water, carburetted hydrogen is abundantly formed; hence arises the gas which is found so plentifully in summer in stagnate waters, which contain quantities of putrefying vegetables."*

"To this," (vegetable decomposition), says Dr. Murray, "the name of putrefactive fermentation has been given. . . . . . The elastic products disengaged are compounds of carbon, and hydrogen, and carbonic acid. . . . . . There is no sensible production of ammonia, or of gases containing sulphur and phosphorus, the evolution of which more particularly characterises animal putrefaction, a difference arising from the absence of these elements and of nitrogen in the composition of vegetables. . . . . .

"Carbon being, in general, the base of vegetable matter, it frequently remains, forming an inert residium after the decomposition has proceeded to a certain extent, constituting what is termed vegetable mould. This, when the air is excluded, is scarcely liable to further change, there being no other principles to act on it with sufficient force.

"It appears that often from the operation of circumstances, probably the exclusion of the atmosphere, and the presence of pressure, the decomposition does not proceed beyond the accumulation of this carbonaceous residium; the former circumstances removing the agency of oxygen, the latter preventing the formation of elastic products; and from the process conducted under these circumstances, and from vegetable matter being originally composed chiefly of carbon, as wood, have probably principally originated the different varieties of bitumen and coal, the origin of which, from the vegetable kingdom, can be so often traced."†

"When vegetables putrefy," says Mr. Donovan, "the changes are not so complex as in the case of animals, because the elements concerned are fewer.

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* Chemistry, by Hugo Reid, pp. 178, 179.

† Chemistry, vol. ii. pp. 570, 571.

"The oxygen combines with hydrogen; another portion of hydrogen combines with carbon. The chief part of the carbon remains as such, unless free access of air be admitted, which then slowly combines with it.

"During the putrefaction of animal and vegetable matter, much heat is produced; and if the mass be considerable, the heat continues a long time."*

It appears from these authorities that, with the exception of carbonic oxide, the products arising from the decomposition of vegetable substances under water, are very similar to some of those which proceed from the decomposition of animal matter; that carburetted hydrogen is the compound gas most abundantly given out; and ammoniacal gases never originate from the decomposition of *vegetable* substances under any circumstances.

Taking into account that the luni-solar current, which flowed in the primitive ocean, and has been so fully described in a previous part of this work, would have the effect of gradually bringing strata of water, charged with gaseous exhalations arising from animal decomposition, over parts of the earth's submarine surface producing plants, and *vice versa,* of carrying the exhalations from decaying vegetable substances over regions inhabited by fixed animals, it remains to be ascertained, what would, in such circumstances, be the probable result when the decomposition of animal substances, by their exhalations ascending into the fluid mass which held the various materials in solution, threw down deposits on the plants.

The products of these decompositions were, as we have repeatedly observed, all gaseous; some of them of considerable specific gravity. Water possesses the capability of absorbing several times its own bulk of many of those which were then present. This would render the portions of water, which were impregnated with those of greater specific gravity, heavier than others and cause them to descend. But on the other hand, those strata of water which were combined with ammoniacal gas being of lighter specific gravity, together with the increased

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* Chemistry, in Cab. Cyc. p. 343.

temperature of the lower aqueous strata in contact with the bottom—where chemical changes were in more active operation—would be caused thereby to ascend, and, by giving place to heavier strata, would produce a continued alternation of currents.* Had the fluid mass, in which those relative movements were taking place, been itself stationary with respect to the solid part of the earth, the currents, whether ascending or descending, would have been in directions perpendicular to the surface; the gaseous elements of reduced specific gravity would have risen directly from the spot of their exhalation. The deposits would have descended from the precise points of their liberation; but when we take into account that the luni-solar attraction, by operating upon the water of the ocean, kept it in a continued flow from east to west, these perpendicular currents would not take place. But by the rule for the composition of forces† we can determine the direction of the ascending and descending particles; it would be a diagonal compounded of the two motions. In this direction, then, the effects of the ascending exhalations would be in operation; while the continued westerly flow of the whole moving mass, by diverting the deposits also from a perpendicular, would co-operate with the other to place them much to the westward of their efficient cause. This divergence, when all the exhalations were supposed to have been of animal origin, was of so little consequence that no notice was then taken of it; but this is now no longer the case, for it becomes very interesting in the

			SPECIFIC GRAVITY.
* Of ammonia water can absorb 670 times its own bulk			0.59027
Muriatic acid	500	ibid	1.28472
Sulphurous acid . . .	33	ibid	2.2222
Chlorine	2	ibid	2.5000
Carbonic acid		ibid	1.04166
Nitrous oxide		ibid	1.18050
Sulphuretted hydrogen . . .		ibid	1.5277
Olefiant gas, or carburetted hydrogen, 1-8th its own bulk			0.5555
Oxygen, and nitric oxide, 1-27th its own bulk			1.5277
Nitrogen, hydrogen, and carbonic oxide, 1-64th its own bulk			1.04166 0.9722

(Chemistry, by Hugo Reid, p. 108, and Dr. Thomson, p. 734).

† Mechanics, in Cab. Cyc. pp. 49, 50.

present stage of our argument, inasmuch as it can be applied to prove that, although the extensive patches of animal and vegetable existences might have been perfectly separate from one another, yet the effects produced by their extinction would, in consequence of the flow of water carrying the compounds formed by their decomposition to great distances, be attended by one universal result over the whole space; and a general deposition, it is presumed, would take place of silex, alumina, lime, magnesia, potash, soda, and oxides of iron and manganese, which, uniting with those already formed in the several localities, would—according to what had already been deposited there—assume the respective forms of clay, shale, or sandstone.

When, by the exhaustion of the exhalations, the disturbing power began to diminish, the aluminous and arenaceous strata—which entombed the calcareous exuviæ of the animals, and the carbonaceous remains of the vegetables—would have attained their maximum thickness; and we have only to carry forward our conceptions a little further, to arrive at a point when, like that to which we formerly alluded, the power which those gaseous exhalations possessed to disturb the general equilibrium, would be proportional to the races which survived the deposition. At this point new creations of vegetable and animal existences, each with an organisation suited to the purified state of the surrounding element, would be essential for effecting a further disturbance of the equilibrium, and an acceleration of the deposits which would result from its derangement. Thus we have a probable explanation of the cause which motived another change in part of the organic life, both vegetable and animal, which encrusted the bottom of the original ocean, the reality of which has been made known to us by the nature of the fossil remains brought to light by the researches of geologists.

These new creations would, in the course of time, be productive of effects quite analogous to those which we have so minutely described, therefore a detailed repetition will be entirely unnecessary. By draining the ocean during *their* lifetime of part of the remaining elementary materials held by it in solution, which were as essential for *their* peculiar secretions

as those which were drained before had been for their predecessors, they would thereby gradually unfit it for continuing to administer to the wants of their own race; while they rendered it more capable of nourishing others of dissimilar habits destined to succeed them, and also brought the whole mass one step further in progression towards its present limpidness and purity. By the exhalations arising from their decay and decomposition, they would gradually though slowly entomb their own remains in a mass of stony matter, whose deposition would also contribute to accelerate the desired change or preparedness of the water; while the combined effect of those several causes would be to add layer after layer of solid, stratified material to the envelope which it pleased the Creator to form around the earth, in order that it might afterwards fulfil the ulterior design he had in view when the whole sphere, thus curiously and elaborately encircled, coat after coat, with rocky strata fitly jointed together, should be caused to revolve around its axis by the introduction of the primary light and its division from the darkness.

Thus far we have gone on endeavouring to explain, in a cursory manner, how we consider the deposition and formation of the secondary strata to have been effected. Difficult as the subject is, from the absence of all direct evidence, and the necessity, therefore, of leaning so implicitly on results, and of tracing them backwards through their progress of accomplishment to their ultimate visible or material causes, we have made an attempt to thread our way through it, yet we do not pretend to go beyond a mere indication of what the process may have been, in the hope that others better qualified may resume and continue the undertaking until they carry it to perfection. Meanwhile we reiterate our belief, that in some such progressive manner, and under the few but comprehensive laws which *then* governed materialism, the depositions and encrustations constituting the secondary strata took place. And, likewise, that science possesses stores of accumulated knowledge sufficient to unravel, with perfect and convincing precision, as much of those operations, during that incipient age of the earth as shall be requisite, in conjunction with the sacred narrative, thoroughly to establish our faith in the

announcements given with respect to what no mortal eye was privileged to behold.

We feel greatly confirmed in this conclusion by the following sublime passage of Scripture:—

"Doth not wisdom cry? and understanding put forth her voice? . . . . . She crieth at the gates, at the entry of the city, at the coming in at the doors; Unto you, O men, I call; and my voice *is* to the sons of man. . . . . . Counsel *is* mine, and sound wisdom: I *am* understanding; I have strength. . . . . . The Lord possessed me in the beginning of his way, before his works of old. I was set up from everlasting, from the beginning, or ever the earth was. When *there were* no depths, I was brought forth; when *there were* no fountains abounding with water. Before the mountains were settled, before the hills was I brought forth: While as yet he had not made the earth, nor the fields, nor the highest part of the dust of the world. When he prepared the heavens, I *was* there; when he set a compass upon the face of the depth; When he established the clouds above; when he strengthened the fountains of the deep; When he gave to the sea his decree, that the waters should not pass his commandment; when he appointed the foundations of the earth: Then I was by him, *as* one brought up *with him;* and I was daily *his* delight, rejoicing always before him; Rejoicing in the habitable part of his earth; and my delights *were* with the sons of men."*

Under these assurances we proceed, next, to enquire how far the findings of geologists, in their researches into the *viscera terræ* bear out the explanations which we have endeavoured to give; and the deductions come to in our attempt to solve the problem by the synthetic method we have pursued. Before doing so, however, it may not be out of place to remind our readers that all they have yet perused has had reference exclusively to the period of non-rotation, or to those ages which we presume to have been briefly alluded to in the first two verses of Genesis. Possessing no other *direct* evidence respecting that prolonged period of the Earth's inchoative condition, we have been constrained to approach the

* Prov. viii. 1, 3, 4, 14, 22—31.

subject indirectly, by endeavouring to apply that which has been revealed as a means of fathoming that which has not been made known, but was wrought out in the depths of the primitive, dark, and atmosphereless water, which circumbounded the Earth while those creative operations were in progress.

This division of our evidence, which we have now nearly brought to a close, may be looked upon as assumptive until confirmed by the facts which geologists, with unremitting assiduity, have made known to us. In the hope that, when compared, these two bodies of evidence may be found to agree, we proceed to give the latter; but should any slight discrepancies occur—and it is possible that they may—we trust the candour and consideration of our friends will induce them to set them down rather to our inability to grasp, with sufficient comprehension, the multitudinous conditions which the solution of such a problem necessarily involves, than to attribute any want of agremeent either to oversight, or to defects in the Revealed Record.

"The coal measures," says Sir Henry de la Beche, in a passage which has been already quoted, "are composed of various beds of sandstone, shale, and coal, irregularly inter-stratified, and in some countries intermixed with conglomerates. . . . . . According to M. de Villeneuve, the coal measures, which are composed of the usual mixture of sandstones, shales, and coal beds, present at the Montagne de S. Gilles, no less than sixty-one beds of the latter, varying from six feet to a few inches in thickness. . . . . . Professor Silliman states, that the beds at Manch Chunk, Pennsylvania, consist of conglomerates, sandstones, and argillaceous slate. . . . . Mr. Hitchcock informs us, that coal is associated with trappean rocks, fetid, siliceous, and bituminous limestones, red and grey sandstones, and conglomerates, in Connecticut. . . . . . By general consent the coal is considered as resulting from the distribution of a body of vegetable remains over areas of greater or less extent, upon a previously deposited surface of sand, argillaceous silt, or mud, but principally the latter, now compressed into shale. After the distribution of the vegetables, other sands, silt, or mud, were accumulated upon them, and this kind of operation was continued irregularly for a considerable time, during which there was an abun-

dant growth of similar vegetables at no very distant place, to be suddenly, or at least in part destroyed, and distributed over considerable areas on the more common detritus.

"Great length of time would be required for this accumulation, because the phenomena observed would lead us to consider the transporting power, though variable, to have been generally moderate; moreover, a very considerable growth of vegetables requiring time, would be necessary at distinct intervals; for coal beds, now only six or ten feet thick, must, before pressure was exerted upon them, have occupied a much greater depth. . . . . .

"From the similarity of general circumstances attendant on the coal strata we have reason to conclude, although the series may contain more limestone at one place than at another, that in Poland, Western Germany, Northern France, Belgium, and the British Isles, there were some common causes in operation producing the envelopment of a great abundance of terrestrial vegetables, of a nature that could not, from the want of necessary heat, now flourish in the same latitudes.*

"The next group which we meet with"—quoting from Mr. Lyell's Elements—"in the descending order is the carboniferous, commonly called 'The Coal,' because many beds of that mineral, in a more or less pure state, are inter-stratified with sandstone, shale, and limestone, of which the bulk of the formation is made up. The combustible itself constitutes but a small proportion of the whole mass. In the North of England, for example, the thickness of the coal bearing strata has been estimated at 3,000 feet, while the various coal seams, 20 or 30 in number, do not exceed 60 feet. . . . . .

"It is now generally admitted that all coal is of vegetable origin, the vegetable structure being still recognizable in many kinds of coal 'when slices thin enough to transmit light are obtained and examined by the microscope, &c.'. . . . . . M. Ad. Brongniart, after comparing the phenomena of the ancient coal and its fossil plants with the great peat mosses of the present day, states, in a memoir published in 1838, that he continues to adhere to the opinions advanced originally by Werner and De Luc, that the vegetation entombed in the carboniferous strata chiefly grew in the localities where the coal is now found.†

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* Manual of Geology, pp. 413—442.

† Elements, vol. ii. pp 104, 106, 127, 135.

Professor Phillips, in his Treatise on Geology, states :—

"That the coal measures, three thousand feet thick in the North of England, consist of abundance of sandstone and shales, layers of iron stone, and beds of coal. Of these there are many alternations constituting a series of many nearly similar terms usually containing at least the three substances—coal, sandstone, and shale; scarcely any limestone occurs in the upper coal measures. . . . . .

"This valuable series of strata, to which Great Britain owes so much of her commercial prosperity, is extended irregularly over the basin of Europe, in North America, Australia, &c. It occupies large breadths in Scotland, Ireland, England and Wales, and lies in patches in various quarters of France, Germany, Poland, and Russia. Commonly it is found at the foot or on the flanks of primary mountains which had been previously uplifted, so that its stratification is not in accordance with theirs.*

In continuation he says :—

"The *organic remains* of the carboniferous system are extremely numerous; upwards of 400 species of animal exuviæ have been figured from the mountain limestone alone: probably 200 species of plants belong to the coal measures; and it is certain that in both these formations considerable additions will yet be made. A few remain to be added from the old red sandstone.

	Coal Measures	Mountain Limestone	Old Red Sandstone
Plants—Marine	1	—	—
Terrestrial	150	—	—
Zoophyta—Polyparia	—	41	—
Crinoidea	—	40	—
Echinida	—	3	—
Mollusca—Conchifera . . . . . . / Plagimyona	10	36	—
Mesomyona	4	24	—
Brachiopoda	—	110	a few
Gasteropoda	1	95	—
Cephalopoda Monoth . . .	—	10	—
Polythal . .	3	78	—
Crustacea—Trilobites, &c.	—	10	a few
Fishes	10?	a few	a few†

* Pp. 100, 101. † Pp. 106, 107.

We shall close the evidence, on this point, with the following vivid delineation from the pen of a talented contemporary:—

"We have now," says Mr. Miller, "entered the coal measures. For seven formations together—from the lower silurian to the upper red sandstone, our course has been over oceans without a visible shore, though, like Columbus in his voyage of discovery, we have now and then found a little floating weed, to indicate the approaching coast. The water is fast shallowing, yonder passes a broken branch with the leaves still unwithered; and there floats a tuft of fern. Land, from the masthead! land! land! a low shore thickly covered with vegetation. Huge trees of wonderful form stand out far into the water. There seems no intervening beach. A thick hedge of reeds, tall as the masts of pinnaces, runs along the deeper bays, like water flags at the edge of a lake. A river of vast volume comes running from the interior, darkening the water for leagues with its slime and mud, and bearing with it to the open sea, reeds and ferns and cones of the pine, and immense floats of leaves, and now and then some bulky tree undermined and uprooted by the current. We near the coast, and now enter the opening of the stream. A scarcely penetrable phalanx of reeds, that attain to the height, and well-nigh to the bulk of forest trees, is ranged on either hand. Their bright and glossy stems seem rodded like Gothic columns, the pointed leaves stand out green at every joint, tier above tier, each tier resembling a coronal wreath, or an ancient crown, with the rays turned outwards; and we see at top what may be either large spikes or catkins. What strange forms of vegetable life appear in the forest behind! Can that be a club-moss that raises its slender height for more than 50 feet from the soil? or, can these tall, palm-like trees be actually ferns, and these spreading branches mere fronds? And then these gigantic reeds! Are they not mere varieties of the common horsetail of our bogs and morasses magnified some sixty or a hundred times? The lesser vegetation of our own country, reeds, mosses, and ferns, seem here as if viewed through a microscope; the dwarfs have sprung up into giants, and yet there appears to be no proportional increase in size among what are unequivocally its trees. Yonder is a group of what seem to be pines—tall and bulky, 'tis true, but neither taller nor bulkier than the pines of Norway and America; and the club-moss behind shoots up its green hairy arms, loaded with what seem catkins, above their

topmost cones. But what monster of the vegetable world comes floating down the stream? It resembles a gigantic star-fish, or an immense coach-wheel divested of the rim. There is a green dome-like mass in the centre, that corresponds to the knave of the wheel or the body of the star-fish; and the boughs shoot out horizontally on every side, like spokes from the knave, or rays from the central body. The diameter considerably exceeds forty feet; the branches originally of a deep green, are assuming the golden tinge of decay; the cylindrical and hollow leaves stand out thick on every side, like prickles of the wild rose on the red, fleshy, lance-like shoots of a year's growth, that will be covered two seasons hence with flowers and fruit. That strangely-formed organism presents no existing type among all the numerous families of the vegetable kingdom. There is an amazing luxuriance of growth all around us. Scarce can the current make way through the thickets of aquatic plants that rise thick from the muddy bottom; and though the sunshine falls bright on the upper boughs of the tangled forest beyond, not a ray penetrates the more than twilight gloom that broods over the marshy platform below. The rank steam of decaying vegetation forms a thick blue haze that partially obscures the underwood; deadly lakes of carbonic acid gas have accumulated in the hollows; there is silence all around; uninterrupted save by the sudden splash of some reptile fish that has risen to the surface in pursuit of its prey, or when a sudden breeze stirs the hot air, and shakes the fronds of the giant ferns or the catkins of the reeds. The wide continent before us is a continent devoid of animal life, save that its pools and rivers abound in fish and mollusca, and that millions and tens of millions of the infusory tribes swarm in the bogs and marshes. Here and there, too, an insect of strange form flutters among the leaves. It is more than probable that no creature furnished with lungs of the more perfect construction, could have breathed the atmosphere of this early period, and have lived.

"Doubts have been entertained whether the limestone of Burdiehouse belongs to the upper old red sandstone or to the inferior coal measures. The limestone of Burdiehouse is unequivocally and most characteristically a coal-measure limestone. It abounds in vegetable remains of terrestrial or lacustrine growth, and these, too, the vegetables common to the coal measures, ferns, reeds, and club-mosses. One can scarce detach a fragment from the mass that has not its leaflet or its seed-cone enclosed, and in a state of such perfect preservation, that there can be no possibility of mistaking its charac-

ter. If in reality a marine deposit, it must have been formed in the immediate neighbourhood of a land covered with vegetation. Now, in the upper old red sandstone, none of these plants occur. The deposit is exclusively animal remains. Its upper member, 'the yellow sandstone,' says Dr. Anderson, of Newburgh, 'does not exhibit a single particle of carbonaceous matter, no trace or film of a branch having been detected in it; though if such in reality existed, there are not wanting opportunities of obtaining specimens in some one of the twenty or thirty quarries which have been opened in the county of Fife, in this deposit alone.' No two bordering formations in the geological scale have their boundaries better defined by the character of their fossils than the old red sandstone and the coal measures."*

Should what we have endeavoured to accomplish, amidst the discouragement arising from the conviction of our incompetency, be the means of pointing the way to a more satisfactory explanation of the manner in which the older strata were deposited from the ocean, which held their elements in mechanical suspension and in chemical solution, it may also explain, to a certain extent, what is mentioned in the *fifteenth* Theorem, of the indication shown by many of the stratiform masses, of *blending* into one another in mineralogical character, when examined in the order of superposition; as we consider that during our investigation we have had occasion to adduce causes sufficient to account for the *blending* of one rock into another, here alluded to. But there is still another peculiarity mentioned in the same Theorem, which it is necessary to notice, namely the "thinning out," or mineralogical *transition* of the strata, when traced continuously to any distance in a horizontal direction.

We shall first show, from undoubted authority, that such is really the case; and, afterwards, endeavour to account for it by an application of the principles we have sought to establish:—

"If you enquire," says Mr. Lyell, "into the true composition of

* Old Red Sandstone, pp. 315—318. We need hardly remind our readers that we consider the earth, at the period alluded to, to have been a sphere of non-rotation, circumbounded by an atmosphereless ocean, tenanted by submerged plants and apulmonic animals.

any stratum, or set of strata, and endeavour to pursue these continuously through a country, it is often found that the character of the mass changes gradually, and becomes at length so different, that we should never have suspected its identity if we had not been enabled to trace its passage from one form to another. . . . . .

"But, notwithstanding the variations before alluded to in the composition of one continuous set of strata, many rocks retain the same homogenous structure and composition throughout considerable areas, and, frequently, after a change of mineral character, preserve their new peculiarities throughout another tract of great extent. Thus, for example, we may trace a limestone for one hundred miles, and then observe that it becomes arenaceous, until it finally passes into sand or sandstone. We may then follow the last-mentioned formation throughout another district as extensive as that occupied by the limestone first examined."*

"The most perfect form of a stratum," Dr. M'Culloch states, "is that in which the two planes are accurately parallel, but it is the most rare. They are more commonly inclined in different ways; so that a bed terminates at length, in one or more directions or in all by a thin edge; while it may also present surfaces so frequently and unequally inclined or undulated, as to be of various degrees of thickness throughout."†

"Professor Sedgwick has shown," says M. de la Beche, "that still further north in England the great line of distinction between the carboniferous limestone and the coal measures are broken up, and that the one rock is lost in the other. . . . . . The alternating beds of sandstone and shale expand more and more as we advance towards the north, at the expense of all the calcareous groups which gradually thin off, and cease to produce any impress on the features of the country. . . . . .

"It may be questioned, at least in parts of Scotland, how far the lines of distinction can be drawn between the upper part of the coal measures and the lower portion of the red sandstone group. Organic remains will be of little assistance; neither is the mineralogical character of much avail, for it will have been seen that this also changes."‡

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* Principles of Geology, vol. iii. pp. 38, 39.

† Geology, by Dr. M'Culloch, vol. i. p. 6.

‡ Manual of Geology, pp. 431—433.

And again he says:—

"A general unconformability does not always prove a movement in the inferior rocks prior to the deposition of the superior; for, supposing a given series so to be produced that the newer rocks may be formed within successively diminishing areas; and another deposit to cover the whole . . . . . this latter would overlap the various members of the former, as they successively fine off."*

Mr. Lyell gives the following opinions on this subject:—

"If we drain a lake which has been fed by a stream, we frequently find at the bottom a series of deposits disposed with considerable regularity one above the other. . . . . . If a second pit be sunk through the same continuous lacustrine *formation* at some distance from the first, nearly the same series of beds is commonly met with, yet with slight variations; some, for example, of the layers of sand, clay, or marl may be wanting, one or more having thinned out and given place to others, or sometimes one of the masses first examined is observed to have increased in thickness to the exclusion of other beds."

And again *mineralogically*:—

"These three classes of rocks, the arenaceous, argillaceous, and calcareous, pass continually into each other, and rarely occur in a perfectly separate and pure form."

"We may sometimes," continues the same writer, "follow a bed of limestone, shale, or sandstone for a distance of many hundred yards continuously; but we generally find at length that each individual stratum thins out, and allows the beds which were previously above and below it to meet."

And, finally from this author—

"The first observers were so astonished at the vast space over which they were able to follow the same homogenous rocks in a horizontal direction, that they came hastily to the opinion that the whole globe had been environed by a succession of distinct aqueous formations disposed round the nucleus of the planet like the con-

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* Note to page 512, Manual of Geology.

centric coats of an onion. But although, in fact, some formations may be continuous over districts as large as half of Europe, or even more, yet most of them either terminate wholly within narrower limits, or soon change their lithological character. Sometimes they thin out gradually, as if the supply of sediment had failed in that direction, or they come abruptly to an end, as if we had arrived at the borders of a sea or ancient lake, which seemed as their receptacle. It no less frequently happens that they vary in universal aspect and composition as we pursue them horizontally. For example, we trace a limestone for a hundred miles until it becomes more arenaceous, and, finally, passes into sand or sandstone. We may then follow this sandstone, already proved by its continuity to be of the same age, throughout another district a hundred miles or more in length."*

Professor Phillips states—

"The local variations in the series of the strata are considerable; several of the stratified rocks are only of limited extent; even whole formations, as the oolitic, change their characters, or, as the millstone grit, are entirely extinct in particular regions where the groups above and below them are complete.

"Another case of stratified deposits deviating considerably from the horizontal, may happen when carbonate of lime is precipitated from solution, and suffered to fall in very tranquil water, on a sloping or undulated bed. The thickness of the strata produced would be greatest in the deepest parts, and the whole deposit would grow thinner towards the edges."†

At a more advanced stage of this work, when we come to explain, how we consider these rocky masses to have been elevated from the horizontal position in which they were formed, we shall have occasion to allude to several phenomena connected with this insensible junction of the strata which have evidently arisen from violent movement and fusion. But at present we shall restrict our observations to only such appearances of this kind as can be traced to the manner of their deposition.

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* Elements of Geology, pp. 6, 27, 64, 198.

† Treatise on Geology, pp. 40, 59, 60.

We have been endeavouring to establish the fact, that the calcareous and carboniferous strata owe their origin, principally, to the propagation of inferior marine animals, and to the spread of imperfect flowerless plants from centres or foci of creation; and we have, therefore, merely to direct the attention to the form which extensive tracts of strata, proceeding from such sources, would naturally assume, whose greatest density would be in their respective centres, to be fully persuaded that they would appear to "thin out" as they approach their common limits, where they would blend entirely together. As far, therefore, as regards their mineralogical differences, and the blending together of the strata, no further explanation is requisite; for they, themselves, demonstrate, in the cause of their accumulation, that also of their sectional form. This enables us to restrict our attention to those enquiries which are connected with the arenaceous and aluminous beds associated with them. These, as we have before explained, we consider to have been deposited from a fluid mass floating above the others; and as this impregnated mass extended alike over all, that which fell from it would, conformably to the laws regulating such depositions, be spread out in horizontal layers of considerable extent, whose upper surfaces would assume a perfect level by first filling up all inequalities of the base which received them. The simultaneous propagation of the testacea, conchifera, and zoophyta, and the spread of the cryptogamous and other imperfect plants would present the appearance of slight elevations and depressions, having their higher parts at the centres, whence the animals and plants radiated; and it is therefore in strict accordance with the laws governing a fluid tranquilly depositing earthy sediment, to infer, that those depressions on the common original base would be gradually filled up by the deposition of layer after layer of earthy material. These afterwards amalgamating with the bounding strata around, would, when finally indurated, present the seeming anomaly "of a limestone bed gradually becoming more arenaceous until it eventually ended in a pure sandstone; or of a coal seam assuming an aluminous structure, and eventually ending in shale."

For a corroboration of this opinion, with regard to the man-

ner in which a fluid mass, holding earthy sediment in solution, deposits this on the bottom, it may be opportune again to refer to and extend the evidence already given, by the following extract from Professor Playfair's Illustrations of the Huttonian Theory* :—

"Loose materials," says that sagacious investigator, "such as sand and gravel, subsiding at the bottom of the sea, and having their interstices filled up with water, possess a kind of fluidity: they are disposed to yield on the side opposite to that where the pressure is greatest, and are, therefore, in some degree, subject to the laws of hydrostatics. On this account they will arrange themselves in horizontal layers; and the vibrations of the incumbent fluid, by impressing a slight motion backwards and forwards, on the materials of these layers, will very much assist the accuracy of their level.

"It is not, however, meant to deny, that the form of the bottom might influence, in a certain degree, the stratification of the sandstones deposited on it. The figure of the lower beds deposited on an uneven surface, would necessarily be affected by two causes; the inclination of that surface, on the one hand, and the tendency to horizontality, on the other; but, as the former cause would grow less powerful as the distance from the bottom increased, the latter cause would finally prevail, so that the upper beds would approach to horizontality, and the lower would neither be exactly parallel to them, nor to one another."†

We have now reached the limit of our present enquiries into the formation of the original stratiform masses of the earth; for we consider the coal measures, with their associated limestone beds, to have constituted the surface, or boundaries of the earth's outer crust, *during the period of non-rotation;* and that the superincumbent masses of more recent epochs owe their collocation to the effects of its first diurnal motion; consequently, in whatever elucidation we may be enabled to present of that stupendous event, these newer formations must assume their proper places.

Before rotation took place, however, it seems apparent that

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* Chapter viii. p. 320, 321.

† Professor Playfair's Works, pp. 58, 59.

successive formations of calcareous, carboniferous, aluminous, and arenaceous deposits succeeded each other, until the ocean was so far drained of its earthy material as to fit it for its ultimate state of equilibrium, and for becoming the pellucid "seas" of our day; and this the researches of geologists assure us actually was the case, as stated on the authority of those writers who have expressed concurring opinions.*

While we have, in our preceding investigations, made it evident that the vast and continued operations then carried on were chiefly effected by the combined instrumentality of zoophyta, of animals, and of plants, whose labours having been performed *under water*, each of the creations of these organized beings, respectively, must have been of the description to which we have, all along, so repeatedly and so persistently alluded: it has thus been made manifest that they did perform the work they were called upon to execute; and, therefore, agreeably to our belief in the attributes of an all-wise and beneficent Creator, no other classes of organic creatures, animal or vegetable, could by possibility have been employed for that purpose, consistently with the incipient state of the earth's creation during its non-rotatory existence.

We trust it may be considered that we have now redeemed the pledge which we gave at the commencement, to prove "*that during the period of the Earth's non-rotation, there were formed, and forming, under its waters, by the united instrumentality of mechanical deposition, of chemical and electrical action, and of animal and vegetable secretion and decomposition, those materials which were afterwards to constitute part of its geological and meterological phenomena; but which had not as yet assumed their present relative position, or their form. That the ocean was also undergoing the necessary preparation for its actual condition. And that the whole of these mighty operations were going forward under the Divine influence, as recorded in the first chapter of Genesis.*"

In immediate connexion with this part of our subject we shall proceed to enquire, whether what has been said with

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* See the ninety-seventh Theorem, already recapitulated in a previous chapter.

respect to the deposition of the earthy material in the form of strata, from the menstruum holding it in suspension, may not afford some clue to unravel what has hitherto been wrapt in mystery, and has occasioned much discussion. We mean the fact, of the primitive ocean having entirely changed its character, from an aggregated mass of earth-impregnated *fresh* water into the present *salt* sea.

This attempt is beset with many difficulties, some of which are peculiar to itself, such as the meagre and sometimes equivocal character of the evidence which we are enabled to bring forward to prove its *original freshness.* Nevertheless, confiding in the truth of what has been adduced, we shall commence by endeavouring to show *that the ocean has not always been salt, although from the first it contained within itself the elements of its saline constitution.*

By the concluding words of the *nineteenth* Theorem, it will be observed, "*that none of the plants discovered in the coal formations have been recognized as being of marine origin;*" while by one of the paragraphs of the *hundred and twenty-fifth* Theorem it is stated "*that in the green sandstone and the chalk, the few species of plantæ which have been found are principally marine.*" We shall now proceed more closely to examine the authorities for these propositions; and in doing so, we shall commence with an opinion given more than half a century ago, although, perhaps, geologically considered, it may not on that account be entitled to greater credit, yet it will serve to point out, how *soon* these facts forced themselves into notice:—

"Now, since it appears," observes Mr. Whitehurst, "that all *strata* accompanying coal universally abound with vegetable forms, it seems to indicate that all coals were originally derived from the vegetables thus enveloped in the stone or clay; and we may say as much of the origin of iron; for the same *strata* also produce iron-stone: for wherever vegetables are observed to decay in stagnant ditches, the waters thereof appear ochory.

"It is a matter worth notice that the superior *strata* contain iron-stone, coals, and vegetable impressions, but NO MARINE PRODUCTIONS WHATEVER. And that the inferior *strata*, which are limestone,

stone, contain the *exuviæ* of marine animals, but NO VEGETABLE FORMS."*

"It was soon remarked," says Professor Henslow, at a much later date, "when the study of fossil vegetables began to attract the attention of botanists, that those from the coal measures were distinct from the plants now existing on the surface of the earth, and that they more nearly resembled the species of tropical climates than such as grew in the temperate zones. Subsequent researches have shown that the species embedded in different strata likewise differ from each other, and that, on the whole, there are about fourteen distinct geological formations in which traces of vegetables occur. According to M. Brongniart, they first appear in the schists and limestones below the coal. These contain a few cryptogamic species (about thirteen), of which four are marine algæ, and the rest ferns or their allied orders. In the coal itself, above 300 distinct species have been recognized, among which those of the higher tribes of cryptogamic plants are the most abundant, amounting to about two-thirds of the whole. Many of them are arborescent, and parts of their trunks are found standing vertically in the spots where they grew. *There are no marine plants in this formation.* A few palms and some gramineæ are the chief monocotyledons; and there are several dicotyledons which have been considered analogous to apocyneaæ, euphorbiaceæ, cactæ, coniferæ, &c. No great stress need be laid at present upon the several proportions which species of these classes bear to each other; as it is probable that subsequent researches will considerably modify them. The great predominance and size of arborescent ferns and other tribes of ductalosæ constitute the main feature of the formation. . . . . . In the green sandstone and chalk few species have been hitherto found, and these are almost all marine."†

"It is a remarkable circumstance," says Sir Henry de la Beche, "connected with the coal measures of the South of England, that *marine remains have not been detected in them*, which, though it does not prove the deposit of coal to have been effected in fresh water, does appear to show that there was something which prevented the presence of marine animals, a circumstance the more remarkable as we have seen that such animals swarmed during the formation of the carboniferous limestone."

* Enquiry into the Formation of the Earth, London, 1786, p. 204.

† Botany, in Cab. Cyc. pp. 311, 312.

A little further on he adds—

"Let us now consider the mode in which the remains of *terrestrial vegetables*, so abundantly preserved in the coal strata, occur."*

"Mons. Ad. Brongniart," says Dr. Ure, "in his Treatise on the Classification and Distribution of Fossil Plants, comes to the following geological conclusions:—1. That in the formations of the coal and anthracite, the vegetables are almost all cryptogamia of the monocotyledonous tribe, such as filices (ferns), equisetum, lycopodiums, marsileceæ, &c.; but the former three families included arborescent species, which no longer exist, except in the first. He therefore doubts the presence of palms in these strata. 2. That few vegetable remains are to be found in the great interval which separates these beds from the upper deposits, and that those which do occur belong almost wholly to marine plants, or to dicotyledonous trees, which appear to have been transported thither by inundations. And 3. That in the higher strata a great variety of fossil vegetables exist, which, for the most part, appear to belong to similar kinds of plants, if not in species, at least in genera, to vegetables which still inhabit the hottest regions of the earth; nor is it probable that they have been transported to our colder ones, since there are sometimes found, as in the lignite of Cologne, trunks of palm trees in a vertical position."†

"Mr Murchison infers," say the editors of the Literary Gazette, "that the coal measures of the great Dudley Coalfields were accumulated exclusively in fresh water."‡

"In the coal formation," say MM. Lindley and Hutton, "which may be considered the earliest in which the remains of land plants have been discovered, the flora of England consists of *ferns* in amazing abundance; of large *coniferous* trees, of species resembling *lycopodiaceæ*, but of more gigantic dimensions; of vast quantities of a tribe analogous to *cactæ* or *euphorbaciaceæ*, but perhaps not identical with them; of palms and other monocotyledons; and, finally, of numerous plants the exact nature of which is extremely doubtful. Between two and three hundred species have been detected in this, the coal formation, of which two-thirds at least are *ferns*."§

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* Manual of Geology, pp. 424, 427.

† New System of Geology, pp. 440, 441.

‡ Literary Gazette, 21st May, 1836, p. 329.

§ Vol. i. pp. x. xi.

"In England," says Mr. Miller, "the formation known as the quartzoze conglomerate is comparatively barren of fossils, the only organic remains yet detected in it being a single scale of the *holoptychius* found by Mr. Murchison; and though it contains vegetable organisms in more abundance, so imperfectly are they preserved that little else can be ascertained regarding them than that they were land plants, but not identical with the plants of the coal measures."*

It is certainly perplexing that at the very outset of our argument we should have to contend against a difficulty which occurs in the only *direct* evidence we possess upon the point we are endeavouring to establish. Professor Henslow's assertion, however, that "of thirteen species of cryptogames discovered in the schists and carboniferous limestone, *four* of them are marine plants," stands too directly in the way to permit of its being passed unnoticed.

In tracing the source from whence the several geological writers seem to derive the evidence for their statements relative to the flora of the primitive world, we are invariably led back upon Mons. Ad. Brongniart, on whose researches and compilations they appear to have reposed great confidence; and hence it results that these various quotations merely tend to prove their united confidence in his judgment and researches; while, it is presumed, that he exercised the like confidence in MM. Sternberg, Schlotheim, Artis, &c., from whom, in truth, he derived much of *his* information. This, of course, must be considered sufficient; but still, on a point of so much importance in its bearing on our argument, it would have been more conclusive to have had concurring testimony from as many independent sources as possible. On the other hand it should be observed, that the whole number of species discovered in the schists and carboniferous limestone are rather limited, being only *thirteen*, of which a third part merely are declared to be *marine*. Professor Henslow unfortunately does not say what these four marine exceptions consist of; and on referring to the copious lists of M. de la Beche, we find he has classed the carboniferous limestone in the carboniferous group, with-

* Old Red Sandstone, p. 196.

out noticing any *marine plant* in that series, and consequently the subject, as far as we are interested in it, is involved in additional obscurity. On tracing back, however, we discover that among the organic remains of the grauwacke group he has included three species of algæ, two of which have been found in Sweden, and one in Ireland, all apparently fucus-formed plants, and these may, perhaps, constitute the marine exceptions to which Professor Henslow alludes. Should this be the case, they must remain as they are until the enigma be explained by some of the numerous casualties which may have occurred to have placed three or four specimens of fossil plants in situations so ambiguous as to occasion their being attributed to the lower part of the carboniferous limestone, or even to the grauwacke group. On this particular point we find a remarkable coincidence in the evidence just given from the standard work of Messrs. Lindley and Hutton, it being there stated, that of the whole fossil flora which have been examined and classed by them, only four species of fucus-formed plants (fucoides) are specifically attributed to any formation associated with or below the coal measures, and they are in the transition series, most probably including the three species of fucoides referred by M. de la Beche to the grauwacke group of that series.

Our readers are, no doubt, aware that the termination "oid," borrowed from the Greek, is applied only when the object to be classed *resembles* but is not *identical* with the order or genus with which it is found convenient to group it provisionally. Consequently, when it is sought to determine, as accurately as possible, whether these four *fucoid* plants were the inhabitants of fresh or of salt water, the fact of their being thus merely allied to the fuci, leaves the question of their real *habitat* entirely open.

And, certainly, where mistakes and misapplications in arranging organic remains according to geological epochs might, in spite of the utmost care and attention, so readily occur, and where a candid desire of the truth is brought to the discussion of subjects involving such general principles as the one does which is now under discussion, an exception which, by assiduity, we have been enabled to narrow down to four species,

and these merely analogous, ought not to stand in the way of our being allowed to employ the main body of the evidence in our future argument.

Considering, therefore, the coal measures themselves to have been wholly formed by the remains of *fresh water* plants, and to have constituted the grand centre of vegetable existence in the primitive world—in which assumption we are confirmed when we reflect, that in them the *absence* of fresh water plants is as much an exception as the *presence* of marine ones is in the grauwacke group, or any formation anterior thereto—they ought to form, as we intend they should, the principal basis of our argument. Besides, it is more consistent to suppose, that the development of the vast but progressive plan of Creation proceeded upon fixed principles, capable of adapting themselves to that progression, than to imagine them subject to capricious changes from salt to fresh water, and from that again to salt. Even supposing it should be eventually established that during the early part of the coal formation, a few species of *fucoid* plants were intermingled with those more purely of fresh water origin, it might be possible, on the well-ascertained capability of plants undergoing remarkable modifications of character without impeding any of their vegetable functions, to explain the anomaly by the supposition that plants so constituted, and, subsequently, found inhabiting the briny ocean, might have grown and flourished in a medium holding soda, lime, magnesia, sulphuric and muriatic acids in solution, but in different combination from what these ingredients are at present; although it may be utterly impossible to conceive that plants *decidedly of fresh water origin* could exist in the present water of the ocean, as these materials are *now* combined in association with them.*

* Theorem 122nd. Mr. Miller, with reference to this elasticity of character in plants, says, "the adaptation which takes place in the forms and constitution of plants and animals, when placed in circumstances different from their ordinary ones is equally striking. The woody plant of a warmer climate, when transplanted into a colder, frequently changes its ligneous stem for a herbaceous one, as if in the anticipation of the killing frosts of winter; and dying to the ground at the close of autumn, shoots up again in spring." (Old Red Sandstone, pp. 71, 72.

We shall proceed, therefore, with the present argument upon the supposition that the ocean, during the earlier geological epochs, possessed all the properties of fresh water, as far as the nourishment of its vegetation was concerned, notwithstanding the presence of the ingredients we have just been treating of. Before proceeding, however, with this chain of argument, there is a *general* prefatory conception to which we are desirous of alluding, from its being essential to the thorough understanding of our subsequent reasoning. It is this: that like most of the other great aggregate bodies (the atmosphere, for example), which, taken together, make up the Earth we inhabit, the ocean, one of these bodies, has peculiar laws impressed upon it, which may, with perfect propriety, be called *constitutional*. That from these normal laws it never very greatly deviates, and to their subjection it has a constant tendency to return, even when deflected therefrom in any degree. That during the non-rotatory period the water of the primitive ocean was gradually approximating towards this static condition; and that, about the time of its close, it had closely approached that state *which was to be for ever afterwards its natural condition;* from which the ocean would only partially, but never materially, deviate in future; and whose constituted power of stability would be such as to enable the sea-water to subdue any minor disturbing cause into obedience with the pervading laws of its constitution. The fixing of this principle in the mind will not only make what we have to say more easily understood, but it will also serve to explain the equability with which the ocean throughout maintains its saltness; being neither rendered more so in mass by local evaporation, nor less saline by the emptying of rivers into it.* To this constitutional state, therefore, we consider the primitive ocean was gradually approaching, by the deposition of those earthy ingredients, which it had held in solution, to facilitate their chemical combinations; while it also conveyed them from one place to another in obedience

* According to Mr. Reid, "the water of the Atlantic ocean within the tropics, contains 1-24th of its weight of saline matters; while that of the Firth of Forth is only reduced to about 1-30th." (Chemistry, p. 118).

to the will, and in conformity with the plans, of the Omnipotent. The carrier-ocean itself being likewise thereby prepared to assume that clear and sparkling state which renders it at once the most beautifully grand, the most wholesome, and the most useful element in nature. Nor can we recognize any objection to this view of the case, or any reason why it should not be admitted that the ocean required to go through a course of preparation for being rendered capable of executing *its* part, any more than that the solid strata, born of it, should require to have been perfected in order to fulfil *their* part in the great unfolding plan of the Creation. On the contrary, we consider it peculiarly characteristic of the attributes of the Creator when we perceive two effects springing simultaneously from one cause, the one co-operating towards the perfection of the other. The ocean approaching nearer and nearer to its own maturity in proportion as it parted with the stony concretions which were forming within its bosom by the several combinations we have endeavoured to explain, while they, crust after crust of mineral strata, as they were depositing, were destined, in turn, when they should be elevated, to become solid defences to the terraine portions of the world, to protect them against the future encroachments of the very element from whence they emanated.

It may be remembered, that when we commenced our investigations into the nature of the deposits which, in all likelihood, were taking place from the primitive ocean, it was considered that silex, alumina, lime, magnesia, barytes, strontites, zirconia, glucina, potash, soda, and ammonia; oxides of various metals, especially iron and manganese, carbonic and fluoric acids, hydrogen and oxygen, with muriatic, sulphuric, and, most probably, nitric acid, were the ingredients held by the ancient water in chemical combination.

In continuation, we went on to explain, first, that by the abstraction of those elements which are known to have been taken from it by animal and vegetable agency; and, afterwards, by the infusion into it of several gaseous exhalations, arising from the decomposition of the animal and vegetable bodies, successive alterations of its equilibrium must have taken place, so as to have brought about new combinations,

and to have caused insoluble precipitates which, in time, became mineral stratiform masses, encrusting the bottom of the ocean. And in this way we accounted for the locking up, in these stony concretions, of the silex, alumina, barytes, strontites, zirconia, glucina, oxides of iron and manganese, fluoric, carbonic, and nitric acids, and part of the lime and magnesia; consequently, we have now to account only for the residue of the magnesia and of the lime, as well as for the soda, potash, and ammonia, and the sulphuric and muriatic acids which remained after the others had become solidified and insoluble.

When the earthy and metallic substances preserved the relationship which has been described, to the muriatic, sulphuric, and nitric acids, and, by their superior affinity towards these acids, excluded the alkalies which, in turn, would combine by *their* affinities with the carbonic acid, *the oceanic water would not, we presume, possess the saline taste and properties which it does at present;* because it has those properties in our day, by the presence of the muriates of soda, magnesia, and lime, and the sulphate of soda, which it holds in saturation in certain determinate proportions, the muriate of soda, or culinary salt, prevailing greatly over all the others. But as soda could not then have been in combination with muriatic acid—it being an axiom in chemistry that an acid will affect the saturating principle in proportion to the strength of its affinity; so, therefore, neither could the taste and qualities which that combination alone confers have been present—hence we may look upon it, without much fear of being wrong, *that up to the time of the carboniferous era, the primitive ocean was not salt.* Moreover, as the substances dissolved in it were held in *chemical* combination, they would, even though in great abundance, detract very little from the limpidity of the water.* Those two essential conditions will account for the possibility of its abounding with *fresh water* plants, in accordance with what is stated in the concluding part of the *nineteenth* Theorem. Neither is this state of

* Lyell's Principles of Geology, vol. i. p. 227. Vide also any analysis of mineral waters.

matters greatly at variance with what occurs at the present day, for it will be observed by the *hundred and tenth* Theorem, *that, besides pure water, the most common ingredients in mineral springs are carbonic acid, sulphuretted hydrogen, carbonates, sulphates, and muriates of soda, of lime, and of magnesia, and carbonate and sulphate of iron. And those of more rare occurrence are sulphurous acid, nitrogen gas, sulphate of alumina, muriate of manganese, siliceous earth, fluoric acid, lithnia, strontia, potash, and hydriodic acid. That as mineral contents are in chemical solution, they rarely, even when in great abundance, affect the clearness of the water. That to hold a large quantity of silex in solution, it seems requisite that the water should be raised to a high temperature. And that, notwithstanding their mineral character, and the high temperature of some of the springs, confervæ and other plants thrive in and close around them.*

Thus we consider we have fulfilled the promise we made when treating of the ancient flora, to prove that, although the water of the ocean contained, from the beginning, the elements which confer on it its saline taste, *yet it was not salt, but fresh*, up to the period when geology can prove, " that the whole of the carboniferous plants were of fresh water origin."

In continuation we must endeavour to show, how the ocean assumed its present saline condition.

What has already been stated will have prepared the mind for entering upon this explanation; for we have accounted for the locking up of nearly the whole of the carbonic acid in forming the shelly coverings of the inferior animals of the primitive era, and in the nourishment afforded to its flora. During the same period, as we also showed, immense deposits of lime took place, not only in completing these coverings, but also in forming the calcareous cement discoverable everywhere in the limestone strata; and the same must, likewise, have occurred with respect to silex, magnesia, and alumina. We were, also, made aware that the introduction of ammonia precipitated the alumina which constitutes the slaty and shaly formations, which, in turn, gave occasion to other changes, causing the simultaneous deposit of more silex, and of magnesia; while phosphuretted hydrogen performed the same

office towards the metallic oxides. That barytes and strontites, from being light and soluble compounds, in union with muriatic and nitric acids, on becoming associated with carbonic and sulphuric acids, were precipitated as the most ponderous of the rocky masses. That fluoric acid holding silex in solution, seems to have entered into the composition of the micaceous deposits which frequently accompany the porcelain earths.* And, lastly, it was shown, on sufficient authority, that earthy precipitates, on being thrown down by the agency of an alkali, generally carry a small proportion of their acid associate along with themselves.

Having in this way accounted for the purification of the primitive water by being deprived of these earthy, metallic, and acidulous ingredients, it will be seen by instituting a comparison between these precipitates and the ingredients which the water was considered to have contained at the commencement, that there remain only to be accounted for, the residue of the lime, magnesia, soda, potash, muriatic and sulphuric acids; and the ammoniacal gas which must have arisen from the putrefactive decomposition of innumerable races of marine animals, during a long but indefinite period; even although a considerable portion of this buoyant gas would be intercepted, in performing other services on its way to the surface.

In conducting the remaining enquiry we shall endeavour, first, to dispose of the *volatile alkali*, which, from its low specific gravity, possesses the peculiar property of conferring on the water a lesser specific weight than it had previous to imbibing it. On a point so essential to our future argument we should wish to base this fact on the securest evidence. Attend, therefore, to what Drs. Murray and Ure state on this point:—

"Ammoniacal gas," says the former, "is largely and rapidly absorbed by water; the water, under a mean atmospheric pressure and temperature, taking up, according to Sir H. Davy, 670 times its bulk of this gas, and acquiring a specific gravity of 0.875. According to Dr. Thomson, water takes up even 780 times its bulk

* Ure's Chemical Dictionary, p. 331.

of ammoniacal gas. Its solution, in water, is of inferior specific gravity to pure water, being usually from 0.900 to 0.936. This gas is expelled from it by elevating the temperature to 136°."*

"The specific gravity of ammonia," says Dr. Ure, "is an important *datum* in chemical researches, and has been rather differently stated. Yet, as no aeriform body is more easily obtained in a pure state than ammonia, this diversity among accurate experimentalists shows the nicety of this statistical operation. MM. Biot and Arago make it 0.59438. Kirwan says that 100 cubic inches weigh 18.16 gr. at 30 ins. of bar., and 61 of Far., which, compared to air reckoned 30.519, gives 0.59540. Sir H. Davy determines its density to be 0.590, with which estimate the theoretical calculations of Dr. Prout in the 6th vol. of the Annals of Philosophy agree. . . . . Water is capable of dissolving easily about one-third of its weight of ammoniacal gas, or 640 times its bulk."

Dr. Ure, after referring to a table "of the quantity of ammonia in 100 parts, by weight, of its aqueous combinations at successive densities, as given in the Philosophical Magazine for March, 1821," and which in general shows a lower specific gravity than pure water, ranging from 0.9000 to 0.99447, goes on to say:—

"The remarkable expansiveness which ammonia carries into its first combination with water, continues in the subsequent dilutions of its aqueous combinations. This curious property is not peculiar to pure ammonia, but belongs, as I have found, to some of its salts. Thus, sal. ammoniac, by its union with water, causes an enlargement of the total volume of the compound, beyond the volume of the constituents of the solution, or the specific gravity of the saturated solution is less than the mean specific gravity of the salt and water. I know of no salts with which this phenomenon occurs, except the ammoniacal."†

In the fact of the specific gravity of water being reduced, when combined with ammonia, or with its salts, we have a remarkable evidence of the all-pervading wisdom of the Creator; for it will be remembered that its introduction into the primi-

* Elements of Chemistry, vol. ii. p. 13.

† Chemical Dictionary, pp. 148, 149.

tive water, when in equilibrium, became the prime mover of many of the chemical changes which followed; while, as its chief action was directed to the aluminous and magnesian earths dispersed throughout the water, in this diminution of specific gravity we recognise an adequate provision having been made for its ascending through, and searching the whole of that enormous mass of liquid; so that none of the parts should escape its penetrating and precipitating influence. And, lest it should be detained in its upward progress—where it was destined long afterwards to act an important part in the future plans of the Creator, a weaker affinity was conferred upon it, for the acids which remained, than was bestowed upon the potash, the soda, the lime, or the magnesia, all of which, as has been already shown, rob ammonia of its acid associates wherever they find them united; and thereby it was left free to pursue its upward tendency.* Hence we may consider it as a legitimate conclusion, that the ammonia, whose low specific gravity, either when pure or when combined with water, caused it to arise in exhalation from putrefying animal substances at the bottom of the ocean, enabled it to continue its course uninterruptedly, while it performed the chemical duties imposed upon it, nor stopped until it reached its destined position amongst the uppermost liquid strata of the primitive ocean, there to await the future designs of the Omnipotent.

With a desire equally as sincere as that which induces us to carry forward our investigations to the very verge of the limits pointed out by scientific research, would we carefully avoid going a single step beyond them. Nevertheless, depending on the sure foundation of the Word of God, when we can discern that it has reference to any field of enquiry not yet fully occupied by philosophy, and such being the case in this instance, we cannot refrain from repeating—what we have already alluded to—that during the non-rotatory period, in a manner somewhat analogous to that in which the nitrogen was created, wherewith to form the atmosphere which was to be willed

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* Ure's Chemical Dictionary, p. 184, and Dr. Murray's Elements, vol. ii. p. 15. Nisbet's Chemistry, and Table of Affinities from Dr. Pearson's Chemical Nomenclature.

thereafter into existence, the material elements, however buoyant, which now constitute the etherial fluid, were wrought out in the dark and shoreless water of the incipient earth, when "the Spirit of God moved upon it;" and created the bases of those works which now demonstrate alike the wisdom, the goodness, and the power of the Creator of the universe.

But to return to our argument.

The disposal of the ammonia, leaves us to deal with the following materials only, all of which, according to the best received opinions, would be combined in the water in their most soluble states, viz., soda, potash, lime, magnesia, and muriatic and sulphuric acids; ingredients which confer on sea water its peculiar saline constitution, as will be seen by referring to part of the *ninety-first* Theorem, which states: "*That, by repeated analysis, sea water has been found to consist of the following ingredients in every* 500 *grains, namely,* 478.420 *of pure water;* 13.300 *muriate of soda, or culinary salt;* 2.333 *sulphate of soda;* 0.995 *muriate of lime;* 4.955 *muriate of magnesia. Wherefore, the ocean, besides the elements of pure water, contains muriatic and sulphuric acids, soda, magnesia, and lime, together with traces of iodine, bromine, and, occasionally, potash.*"

A more detailed examination of the evidences for this conclusion, will give us the following particulars:—

Sir Henry de la Beche states, that "according to Dr. Marcet, 500 grains of sea-water, taken from the middle of the North Atlantic, contained,

Muriate of soda	13.3
Sulphate of soda	2.33
Muriate of lime	0.995
Muriate of magnesia	4.995
	21.580."*

Dr. Ure, in his comprehensive table of mineral waters, gives for sea-water the following results, viz.:—

	GRAINS.		GRAINS.
Water	7291	Muriate of lime . . .	5.7
Muriate of soda . .	159.3	Sulphate of soda . . .	25.6
Muriate of magnesia .	35.3	Sulphate of potash .	a trace†

* Geology, p. 3.

† Chemical Dictionary, p. 280.

Dr. Murray says, that sea-water, on the principle that the most soluble salts will be those existing in solution, will contain in a pint,

Muriate of soda	159.3	grains
Muriate of magnesia . . .	35.5	,,
Muriate of lime	5.7	,,
Sulphate of soda	25.6	,,*

Finally, as regards the evidence on this point, although it may, in some degree, be an anticipation of our subsequent reasoning, we can hardly pass onwards without alluding to another concurring cause, which consisted in the introduction of the primary light into the material universe on the first day of the Mosaic week, whose electrical effects would thereafter tend, perhaps, more than any other influence, to complete the perception of saltness by means of the pre-existing saline elements.

Having thus reached a point where our argument *a priori* coincides with the conclusions of experience, deduced from actual analysis of sea-water, we trust it may be considered that the steps which have led us to it have also been correct. When we reflect on the progressive character of the process which transformed the ocean, from a boundless reservoir of earthy mineral water, with its saline ingredients and properties neutralized by the presence of substances possessing greater affinity for the acids than the fixed alkalies, whose union with them is now the cause of its saltness; and, at the same time, consider, that the deposition which took place from the water, of these earthy materials which now form the rocky beds of the earth's outer crust, extended in duration from the earliest geological epoch wherein regular strata can be detected, up to the latest of the coal measures, and that these stupendous depositions were many ages in being effected, we have every reason, also, for concluding, that the sea acquired its saltness by degrees, and, therefore, that the successive families of plants would correspond, in every respect, to the predominant constitution of the element during that particular period in which

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* Elements of Chemistry, vol. ii. p. 396.

each was destined to grow; while, as an evident and final deduction from these truths, we may come to the conclusion that *marine plants*, or those most resembling them, such as the fucoides, would be discovered only amongst the *latest* series of the coal measures, or embedded in some ones above them, such as the tertiary strata, which are of still later formation.

Before quitting this portion of our labours, and whilst the circumstances are fresh upon the mind which bring out, so clearly and delightfully, the wisdom which devised, and the power and skill which wrought out these beneficent ends by such numerous instruments, through protracted ages and on a scale so vast, we cannot more appropriately offer up the tribute alike of our adoration and our thanksgiving, than by adopting the language of the xcv. Psalm, and proclaim with one voice, "The sea is his, and he made it; and his hands formed the dry land. O come let us worship and bow down, let us kneel before the Lord our maker. For he is our God, and we are his people!"

SECTION V.

INTRODUCTION OF THE LIGHT; THE CONSEQUENT PROTOROTATION OF THE EARTH; AND ITS DYNAMICAL RESULTS.

CHAPTER XIII.

Prefatory observations. Condition of the Earth during the period alluded to. Introduction of Light into the material universe. Contrast between the prolonged operations of the non-rotatory period, and the sudden completion of the work of creation during the Mosaic week. The relative qualities of Light—its cuasi-ubiquity, expansion through visible space, velocity of propagation, and vividity. Heat the cause of expansion in material bodies. The source of external Light and Heat received by the Earth. Identity of these two subtile influences. Sun-light the direct cause of Heat. Attraction and Expansion the antagonistic forces which maintain all matter in its constitutional state of equilibrium. Deduction from these facts, that Darkness, in the language of Genesis, means Attraction. Philological and scientific analogies in favour of the same conclusion.

At the period to which we alluded when we closed the last section, the earth was considered to have been a spherical planet, whose horizontal rocky crust—beneath a dark and atmosphereless ocean—was covered in some places by dense vegetation, and in others teemed with inferior animal life; while the primeval water, though drained of its metallic ingredients, and most of its suspended earths and acids, still retained some of the two latter, and a proportion of the original alkaline and acidulous elements: and that, thus constituted, the earth was looked upon as circulating round an unillumined sun, in obedience to the same laws which still govern its periodical motion; and in precisely the same orbit wherein it continues to perform its annual revolution.

The great movements of the orbs in space had, long ere the period we allude to, reached a state of equilibrium, from which nothing but a fiat from the Omnipotent can ever cause them to depart; but, as regards the earth itself, it is to be borne in mind, that according to the same immutability of the laws which govern every particle of matter, the primeval water might, by a continuance of the purifying process, if it had so pleased Heaven, have gone on parting with elements until it became inconceivably more aeriform than it ever was destined to be. Still, being material even under these imaginary circumstances, it would have reached a point, and have assumed a state of equilibrium, from which, until the laws were changed, it could not possibly have departed. For without the direct and opportune interference of a power beyond itself, and of adequate influence, the non-rotating earth, with all its concentric stony encrustations, its myriads of living beings, with its dense, sub-marine fields of gigantic plants, and its limpid, but dark atmosphereless water, must have continued for ever to have circulated, in annual orbit, around the unillumined sun, without any further progress having been made in the work of Creation. A little more attention and assiduity will, however, bring us to a point where we shall perceive that the world was not destined to be left in this unfinished condition; but that God, from everlasting, had foreseen this exigency; and did, in due time, *by the creation of the light, and its division from the darkness,* introduce into the material universe a power sufficient to impel the work onwards until it was completed.

With these prefatory observations—which are intended to prepare the mind—we shall proceed with the further development of our views; while we shall adhere, as closely as possible, to the same method of effecting it.

The condition described at the beginning of this chapter, is that in which we consider the earth to have been, while, in the impressive language of Scripture, "darkness was upon the face of the deep;" and that it continued so until every atom of superfluous earth was precipitated from the water, and until the last plant or creature had fully executed the object for which it was brought into existence. For so manifest is the design which prevails throughout the whole, and so minute

the superintending care of the Omnipotent Creator, that the strongest conviction is impressed upon the mind, that so long as a single grain of silex, intended to aid in the formation of any of the numerous stony concretions at the bottom of the ocean, had not as yet been separated from the water, and placed in its destined position, no change would be commanded to take place in the great governing laws of the universe; while, on the other hand, we are constrained also to believe, that whenever the last particle had subsided, not one instant of time would elapse until the fiat went forth which should change the whole face of Creation; and the material universe, from an unillumined congeries of spheres, revolving in the dark womb of nature, should be transformed into a radiant universal galaxy of worlds, shining in the beams of the new-formed light, "when the morning stars sang together, and the sons of God shouted for joy."

In prosecution, therefore, of our subject, we are now to consider that the moment had arrived, which was foreseen from all eternity, when plants and animals had—for the time being—alike fulfilled their destined functions, and the last material particle designed to be separated from the primitive water, and aggregated to the solid earth beneath, had reached its destination, and the august command, "Let there be light," was resounding throughout the universe; sufficiently vouched for by the obedient response recorded by the inspired historian, who immediately adds "And there was light." After dwelling for a moment with feelings of adoration and astonishment on whatever we can comprehend of the attributes and infinite power of that Being who could thus command and be obeyed by all nature; and being filled with love for the unbounded goodness which caused such a gracious act of volition, let us, in humble dependance on his aid, endeavour to determine the results of this important and transforming announcement on the state, the motions, and the materials of the hitherto non-rotating, watery-bound sphere, "without form and void;" but which, with pleasing variety of hill and dale, of land and water, and in the enjoyment of the vicissitudes of day and night, and summer and winter, now forms the mighty pedestal whereon myriads of beings, adapted to its altered condition,

are wheeled with rapid but unconscious speed through the prescribed regions of space.

In attempting this arduous undertaking, the conceptions which crowd upon the attention are so numerous, and have reference to so many and to such stupendous operations, that they almost overwhelm, and leave the mind in a condition to be scarcely able to deal effectually with any of them.

Hitherto our investigations have had reference to works carried on throughout periods of long duration, but of so progressive a character that leisure was afforded for careful examination, as they went on, step by step, towards perfection; and composure was enjoyed to note down the successive events which were taking place beneath a shoreless ocean, and upon a motionless sphere, where all was still and slowly progressive. But from the period to which we have now to refer, when the prime mover, LIGHT, was introduced by the Omnipotent amongst the materials which he had prepared, the whole aspect of creation suddenly changed, and events of transcendental importance succeeded each other with astounding rapidity. Those elements which had been the work of ages to create were now, within the limited space of six days, to be all remodelled, fashioned and framed, the works of his hands, and made to occupy the relative positions on the land, in the sea, and throughout the air, for which they had been designed from all eternity! Where darkness reigned almost paramount before, material light was introduced to be its powerful and active competitor. The dark, slumbering, shoreless ocean was made to rush, wave over wave, with impetuous haste, from the poles towards the equator, so soon as the finger of God, by causing the earth to rotate, had marked off those points, hitherto non-existent, upon the surface of the non-rotating sphere; while the great continental ridges of the world, raised their huge backs from beneath part of that agitated ocean to restrain it in future within the hollow cavities which simultaneously sank down in humble obedience to the Creator's will. And the elements of the atmosphere, ejected far into space by the same proto-motion, were there transfixed by their decreed union with light, and never allowed to return; but there retained, as the life-sustaining atmosphere.

But it is Light, the chief secondary agent in producing all these wondrous effects, to which we would, at present, more particularly direct the attention.

In doing so, it is not our design to enter into any discussion as to the *intimate* nature of the light, which, on the first day of the Mosiac week, was willed into existence; for such an undertaking as this would be, we are well aware, no human being could successfully accomplish. But we may briefly premise, that we consider it to have been of a kin to the invisible light and heat which are united in and can be engendered by *electrical excitement; that* powerful but imperceptible fluid, for example, which results by completing the voltaic circuit, and that not until the *fourth* day of the Mosaic week was *visible* light willed into existence. We firmly believe, that whatever may be the nature of light, it was *complete in itself, on the first day*. *before* it was divided from the darkness; that there were, therefore, two separate and sequent acts of creation with respect to this important element. One whereby *light*, whatever it is, was willed into existence, and (as we shall presently more fully explain), caused to pervade all materialism; and another whereby a certain *state* or *condition*, distinct from its *intimate* nature, was conferred upon it, by its being "divided from the darkness." And, finally, we believe that the light, in its condition of division from the darkness, constituted and still constitutes an indispensable element in the existence of all organised beings, throughout the material universe, which are in part composed of a nervous system, and dependant on this and atmospheric air for their powers of locomotion. That, in fact, it formed the great base or groundwork preparatory to the introduction of all such animated beings, who could no more have performed their nervous functions without this all-pervading element, than they could continue their respiration independently of the atmosphere. This fundamental fluid being all throughout and everywhere the same, the diversity of the creature consequently consists in the modification of *its* form.

But, leaving generalities, we shall now proceed with the more direct line of our argument.

In scanning the portion of Scripture to which our present investigations refer: "And God said, Let there be light: and

there was light," it is not unusual to attribute, by the promptitude of the *response*, as it were, "And there was light," a signification almost exclusive of *power*. We feel disposed to imagine, however, that besides the incontestible evidence of Omnipotency which these two passages so clearly display, they, at the same time, convey a meaning equally as wonderful by the UBIQUITY of the *light* which they make so manifest. As this remarkable characteristic of light will form an important datum in our future reasoning, we shall, on that account, have to go into the evidence connected with it somewhat in detail. Meantime, we may observe, that we look upon the element, which is recorded to have been formed on the *first* day of the Mosaic week, to be the most *immaterial* of all material substances created by God. We are well aware of the difference between materialism and immaterialism, and have no intention of confounding them; we merely wish to convey, by these assertions, a conception of the tenuity, subtility, and buoyancy of light. It was the Creator's chief agent, of a material kind, in accomplishing the six days' work recorded by the inspired historian; it emanated directly from God; had no special locality assigned to it; and, before it was created, the spirit of God, by his "movement on the face of the waters," produced effects which, although material light could not have accomplished them, yet they were entrusted to this latter agent, for ever afterwards, to be continued and preserved in the condition to which they were brought by his immediate influence. And, in continuation, we may express our belief, that the LIGHT to which we allude pervades all materialism; that there are not any two points, however remote from each other, in the universe, which have not the space between them filled up with light; while its penetrating minuteness is the admiration of all who have paid any attention to its wonderful developments.

But let us verify these general assertions by evidences derived from science. In doing this, we shall recapitulate the *thirty-eighth* Theorem, and afterwards give some of its authorities in detail.

"*That light, according to the Newtonian hypothesis, is supposed to consist of inconceivably minute, material particles,*

emitted by luminiferous bodies, and moving through space with the velocity of 192,000 *miles in a second of time. That, according to the Undulatory Theory, an exceedingly thin and elastic medium called* Ether *is supposed to fill all space, and to occupy the intervals between the particles of material bodies; and that the vibrations or undulations of this etherial medium cause the sensation of* Light.

"*But whatever may be the mode by which it is considered that light becomes perceptible, its universality, and the almost immeasurable distance at which it is perceived throughout space, as well as the amazing rapidity of its vibrations requisite to convey sensations of colour are alike remarkable.*"

In selecting the evidences, we shall, for the present, restrict them to those bearing upon the *ubiquity* of light, whether as regards its universality throughout space, or its searching penetrability and minuteness. Upon its velocity a few passages will suffice, and these we shall first submit.

Sir David Brewster states—

"That light moves with a velocity of 192,500 miles in a second of time. It travels from the sun to the earth in seven minutes and a half. It moves through a space equal to the circumference of our globe in the eighth part of a second; a flight which the swiftest bird could not perform in less than three weeks."*

Mrs. Somerville observes—

"This circumstance (namely, a difference in the time of the eclipses of the satellites of Jupiter, according as this planet is in conjunction or in opposition), is attributed to the time employed by the rays of light in crossing the earth's orbit, a distance of about 190,000,000 miles; whence it is estimated that light travels at the rate of 190,000 miles in a second."†

Sir John Herschel says—

"Roemer (a Danish astronomer, in 1675), speculating on the probable physical cause of the difference in the times of the eclipses of Jupiter's satellites, was naturally led to think of the gradual,

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* Optics, Cab. Cyc. p. 2.

† Connexion of the Sciences, pp. 37, 38.

instead of an instantaneous propagation of light. This explained every particular of the observed phenomenon, but the velocity required (192,000 miles per second), was so great as to startle many, and, at all events, to require confirmation. This has been afforded since in the most unequivocal manner."*

It is stated in the "Connexion of the Sciences," with reference to the intensity of this subtile element, that—

"The intensity of light depends upon the amplitude or extent of the vibrations of the particles of ether; while its colour depends upon their frequency. The time of the vibration of a particle of ether is, by theory, as the length of a wave directly, and inversely as its velocity."

And after describing the delicate and ingenuous method employed by Sir Isaac Newton, and others, to compute the frequency of these vibrations, it is further said—

"Now, as Sir Isaac Newton knew the radius of the curvature of the lens, and the actual breadth of the rings in the parts of an inch, it was easy to compute that the thickness of the air at the darkest part of the first ring is the $\frac{1}{89000}$th part of an inch, whence all the others have been deduced. As these intervals determine the length of the waves on the undulatory hypothesis, and as the time of a vibration of a particle of ether producing any particular colour is directly as a wave of that colour, and inversely as the velocity of light, it follows that the molecules of ether producing the extreme red of the solar spectrum perform 458 millions of millions of vibrations in a second of time; and that those producing the extreme violet accomplish 727 millions of millions of vibrations in the same time. . . . The determination of these minute portions of time and of space, both of which have a real existence, being the actual results of measurement, do as much honour to the genius of Newton as that of the law of gravitation."†

"According to the undulatory theory," says Sir David Brewster, in the Treatise on Optics, "an exceedingly thin and elastic medium, called ether, is supposed to fill all space, and to occupy the intervals between the particles of all material bodies. The ether must be so

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* Astronomy, Cab. Cyc. p. 466.

† Pp. 190—193.

extremely rare as to present no appreciable resistance to the planetary bodies which move freely through it.

"The particles of this ether are, like those of air, capable of being put into vibrations by the agitation of the particles of matter, so that waves or vibrations can be propagated through it in all directions. Within refracting media it is less elastic than in vacuo, and its elasticity is less in proportion to the refractive power of the body. When any vibrations or undulations are propagated through this ether, and reach the nerves of the retina, they excite the sensation of light, in the same manner as the sensation of sound is excited in the nerves of the ear by the vibrations of the air. Differences of colour are supposed to arise from differences in the frequency of the ethereal undulations; *red* being produced by a much smaller number of undulations in a given time than *blue*, and intermediate numbers of undulations.

"In a work like this it would be in vain to attempt to give a particular account of the principles of this theory. It may be sufficient at present to state that the doctrine of interference is in complete accordance with the theory of undulation.

"The following table given by Mr. Herschel, contains the principal data of the undulatory theory:—

Colours of the spectrum.	Length of an undulation in parts of an inch.	Number of undulations in an inch.	Number of undulations in a second of time.
Extreme red	0.0000266	37,640	458,000000,000000
Red	0.0000256	39,180	477,000000,000000
Intermediate	0.0000246	40,720	495,000000,000000
Orange	0.0000240	41,610	506,000000,000000
Intermediate	0.0000235	42,510	517,000000,000000
Yellow	0.0000227	44,000	535,000000,000000
Intermediate	0.0000219	45,600	555,000000,000000
Green	0.0000211	47,460	577,000000,000000
Intermediate	0.0000203	49,320	600,000000,000000
Blue	0.0000196	51,110	622,000000,000000
Intermediate	0.0000189	52,910	644,000000,000000
Indigo	0.0000185	54,070	658,000000,000000
Intermediate	0.0000181	55,240	672,000000,000000
Violet	0.0000174	57,490	699,000000,000000
Extreme violet . . .	0.0000167	59,750	727,000000,000000

"'From this table,' says Mr. Herschel, 'we see that the sensibility of the eye is confined within much narrower limits than that of the ear; the ratio of the extreme vibrations being nearly 1.58 : 1

and, therefore less than an octave, and about equal to a minor sixth.

" 'That man should be able to measure with certainty such minute portions of space and time is not a little wonderful; for it may be observed, whatever theory of light we adopt, these periods and these spaces have a *real existence*, being, in fact, deduced by Newton from direct measurements, and involving nothing hypothetical, but the names here given them.' "*

We shall follow up these evidences, as to the velocity and the minuteness of the vibrations of light, by some extracts regarding its wide-spread expansion throughout space.

The author of the *Architecture of the Heavens*, in his impressive language, says—

"The nebulæ whose general aspect I am about to describe, present very various appearances to the telescope. In many of them individual stars are distinctly defined. As they become more remote the distance or intervals between the stars diminish, the light also growing fainter; in their faintest stellar aspect they may be compared to a handful of fine sparkling sand, or as it is not inaptly termed, "star dust;" and beyond this we see no stars, but only a streak or patch of milky light, like the unresolved portions of our own surrounding zone. . . . .

"It was a bold conception, after having recognised the great meaning of these nebulæ, to undertake to compute their relative distances and to lay down their plan. But, undaunted even by the idea of the firmamental universe, Herschel undertook to fix what it was within reach of his telescopes, and of course, what it might be beyond them. . . . . By using comparatively small telescopes he determined the remoteness of 47 resolvable clusters, *ten* of which were upwards of 900 times more distant than Sirius. Suppose a cluster as ascertained to be of the 900th order of distances were first seen by a telescope whose space-penetrating power is 10, it is easy to compute how far off it must be to be descried as a faint spec by an instrument whose power is 200—it would evidently be at the enormous remoteness of 18,000 times that of Sirius! Very many unresolved clusters are undoubtedly as profound, and many still profounder in space. . . . . . Herschel reaches the depth of

* Optics, Cab. Cyc. pp. 134—136.

the 35,175th order of distances, in which some of these nebulæ must be. . . . . . . A forty feet reflector could descry a cluster of stars, consisting of 5,000 individuals, were it at the remoteness of 11,765,475,948,678,678,679 miles, and in fact the limits to the power of such an instrument being only *an object fainter than the general light of the skies constituted by the intermingling of the rays of all the stars.*

"We, of this time, may do little more than roughly chart the boundary line," of the vast firmament; "the filling up and mapping of the details constitute a harvest for the future. But how soon may that future come! The wheels of time are revolving rapidly—truth mingling with truth, as light gathered into a focus—alike within and around us, cause events to succeed without the usual interval; nor is astronomy unaffected by the general acceleration. . . . . . What triumphs, what delights are awaiting us! yet once more shall new views dawn upon mankind; yet once more will some favoured eye first track a vast unknown."*

More conclusive evidences than these, of the almost immeasurable expansion of light throughout the universe, or of the extreme rapidity of its vibrations, need scarcely be desired. Indeed, the tongue can hardly repeat the numbers which the foregoing array of figures denotes, nor the mind imagine the almost illimitable immensity of space to which they have reference; while it should be remembered, that, as far as the human eye—armed with the most powerful lenses—is concerned, these vast distances at which luminous objects are visible—these vanishing points of light—extend in every direction, as from a centre, around our mundane spec, that they are as remote in every quarter of the heavens as in any one region!

Nothing appears wanting, therefore, to show the universal diffusion of light; or the almost inconceivable velocity of its undulations, whereby it seems to shrink, as it were, as far from our perception by *minuteness*, as it spreads itself throughout space *in extension.*

The all-pervading nature of light having been thus satisfactorily established, we have next to combine it with the no less

* Architecture of the Heavens, Nichol, 1837, pp. 48, 54, 39, 102, 103.

certain fact of its having *been complete in itself before* that *state* or *quality* which divides it from the darkness was impressed upon it. And here we may observe, that the boundless stores of SCIENCE, varied and delightful as they are, may be ransacked in vain without imparting to us the slightest information on this particular point. Yet we know, upon the irrefragable authority of him who formed it, that such was the case. That there was a time—however evanescent—when the LIGHT, *before* it was divided from the darkness, was complete and whole in itself, and lacked nothing. It *was* light, but quiescent light, as yet undivided from the darkness; for it is recorded, where no mistake can occur, that in that condition "*God saw that it was good.*" When we come to treat of the atmosphere we shall show, that the expressions to "divide" one thing from another used in this part of Scripture, signifies to give the two opposite motions in space. But we shall not delay at present to enquire into that point, it being sufficient for our purpose to lay down the two bases, *that there was an instant of time when the light, though complete, was without motion, and that, as near as matter can be said to be, it is ubiquous.*

Holding these two dominant qualities of light steadily in the mind, and pondering over their united effect upon the act of conferring motion upon that subtile element, it is impossible to come to any other conclusion than *that the motion impressed upon it would be one of* VIBRATION *or* UNDULATION.

It can be easily imagined that throughout any space, however vast, which is completely filled by an elastic medium, however ethereal (and the more ethereal the greater tension and effect), a vibratory motion may, when engendered, be propagated and transmitted with the utmost rapidity. But, it seems wholly inconceivable, on anything like philosophical principles, to imagine, that *particles of matter*, however minute, subtile, or penetrating, which, *before* motion was communicated to them, filled all space, could be *made to travel* through the identical space which was filled with them previously.

If the sea surrounded our globe in any continuous zone whatever, a motion of undulation communicated to it at any

part might be imagined capable of being transmitted throughout its endless extent, round and round. But it could not, for a moment, be conceived, that the particles of water themselves could travel onwards unless in a continuous mass or body. And the same holds good with regard to the ethereal ocean which permeates the immensity of space.

This brings us a stage nearer to the point at which we wished to arrive; and leads to a further and more important consideration of the same combination, namely, the *ubiquity* of the ethereal element, and the fact that *there was a time*, however brief, when light *existed, complete in itself, but without* having been divided from the *darkness*. What this latter point means we shall, in the sequel, endeavour to make apparent; meantime it is sufficient if we concur with the announcement, that *after* God had seen and had declared the light to be "good," he "divided it from the darkness."

The results arising from these operations will, on investigation, be found to have been most momentous. The introduction of this new force into the material universe, as the first act of creative power during the Mosaic week, amongst materials which had occupied ages to prepare for its reception, will show us, as we proceed with our enquiries, that light, and especially its ubiquity and its division from the darkness, caused it to become the prime[*] material mover in almost all the stupendous operations of that eventful week, which were designed, from everlasting, to follow in the sequence in which they stand recorded.

What light was *before* it was divided from the darkness no mortal, perhaps, ever shall know. Fortunately for our present argument it is sufficient that we do know, on authority which dares not be doubted, *that it did once so exist*, and that a reliance on this assurance can serve as a competent fulcrum to raise the weight which we propose to do by its means. Although, from the very nature of the subject, we shall have to make rather an indirect approach towards the main point, and affected, in common with all others, by the undiscoverable nature of original light—that is—light before it was divided from the darkness, we shall have to reason *from what it now is to what it probably was*, in the expectation, that when we reach that

position, we may be able to estimate, somewhat approximately, the effects which would necessarily proceed from the second recorded act of the Creator's omnipotent power—his "*dividing the light from the darkness.*"

The first point in this new chain of argument to which we have to direct the attention, is to prove, that the presence of *heat* and *light* invariably causes expansion.

In effecting this we shall commence by recapitulating what is contained in the *fiftieth* Theorem, "*That the first and most usual effect of heat is to increase the size of the bodies to which it is imparted, by causing them to dilate or expand. That, although these effects are produced in different degrees and by different methods, according as the body to which heat is applied be solid, liquid or aeriform, yet it may be considered as a physical law to which there is no real exception, that an increase in the temperature will be accompanied by an increase of volume, and a diminution of temperature by diminution of volume. And that the force with which solids and liquids expand or contract by heat or cold is prodigious.*"

In another part of the work from which this is taken, it is added—

"We have seen that when heat is imparted to a body its dimensions are immediately increased; and it is found that this increase takes place equally throughout every part of the dimensions, so that the figure or shape of the body is preserved, every part being enlarged in the same degree. Now, this effect must be produced by the constituent particles of the body moving to a greater distance asunder; and since the increase of diminution takes place equally throughout every part of the volume of the body, the component particles must be everywhere separated equally. In fact, they have driven each other to a greater distance asunder, and a repulsive force has consequently been called into action."*

Sir John Herschel, in his Treatise on Natural Philosophy, expresses himself thus, on the same subject:—

"The dilatation of bodies by heat forms the subject of that branch

* Heat, in the Cab. Cyclopædia.

of science called pyrometry. There is no body but is capable of being penetrated by heat, though some with greater, others with less rapidity; and being so penetrated, all bodies (with a very few exceptions, and those depending on very peculiar circumstances), are dilated by it in bulk, though with a greater diversity in the amount of dilation produced by the same degree of heat."

And, in continuation, he adds—

"But solids themselves, by the abstraction of heat, shrink in dimension, and at the same time become harder and more brittle, yielding less to pressure, and permitting less separation between their parts by tension. These facts, coupled with the greater compressibility of liquids, and the still greater of gases, strongly induce us to believe that it is heat, and heat alone, which holds the particles of all bodies at that distance from each other which is necessary to allow of compression; which in fact gives them their elasticity, and acts as the antagonistic force to their mutual attraction, which would otherwise draw them into actual contact, and retain them in a state of absolute immobility and impenetrability. Thus we learn to regard heat as one of the great maintaining powers of the universe, and to attach to all its laws and relations a degree of importance which may justly entitle them to the most assiduous enquiry."

In the "Connexion of the Sciences" it is stated to be

"A general law, that all bodies expand by heat and contract by cold. The expansive force of caloric has a constant tendency to overcome the attraction of cohesion, and to separate the constituent particles of solids and fluids; by this separation the attraction of aggregation is more and more weakened, till at last it is entirely overcome, or even changed into repulsion."*

"Whatever," says Mr. Donovan, "the nature of repulsion may be, it is found to be in some manner connected with what we call *heat*. Corpuscular repulsion is found to be increased by the presence of heat, and diminished by its absence. When heat increases the repulsion between the particles of a body, these particles must recede further from each other in all directions; and if they all take more remote stations, it is obvious that the bulk of the body must

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* Mrs. Somerville, p. 243.

be increased: it is now, in fact, larger, although the quantity of matter remains the same, and it is said to be *expanded*."*

We shall next direct the attention to a part of the *second* Theorem, namely, "*that the Earth is a non-luminous body, receiving its external light and heat from the sun;*" and, in continuation, proceed with some of the evidences on which that assertion is founded.

Sir John Herschel, in his Treatise on Astronomy, says—

"Henceforward, then, in conformity with the above statements, and with the Copernican view of our system, we must learn to look upon the sun as the comparatively motionless centre about which the Earth performs an annual elliptic orbit of the dimensions and eccentricity, and with a velocity regulated according to the law above assigned; the sun occupying one of the foci of the ellipse, and from that station quietly disseminating on all sides its light and heat."

And again—

"The sun's rays are the ultimate source of almost every motion which takes place on the surface of the earth. By its heat are produced all winds, and those disturbances in the electric equilibrium of the atmosphere which give rise to the phenomena of terrestrial magnetism, &c. &c. . . . . . . The great mystery, however, is to conceive how so enormous a conflagration (if such it be), can be kept up. Every discovery in chemical science here leaves us completely at a loss, or, rather, seems to remove farther the prospect of probable explanation. If conjecture might be hazarded, we should look rather to the known possibility of an indefinite generation of heat by friction, or to its excitement by the electric discharge, than to any actual combustion of ponderable fuel, whether solid or gaseous, for the solar radiation."

In the article on heat in the Cabinet Cyclopædia, it is stated—

"From this it appears that the only external source of appreciable heat to the earth is the sun."

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* Chemistry, in Cab. Cyc. p. 40.

Sir Henry de la Beche, in his Manual of Geology has the following sentence :—

"The superficial temperature of our planet is certainly very materially influenced by, if it may not be entirely due to, solar light and heat. That the difference of seasons and of the climates of various latitudes originates in the greater or less exposure to the sun is obvious. That local circumstances cause great variations of superficial temperature, is also well known; yet the principle seems to prevail that, under equal circumstances, the temperature decreases from the tropics to the poles."

In the "Connexion of the Sciences" it is said—

"The ocean of light and heat perpetually flowing from the sun must affect the bodies of the system very differently, on account of the varieties in their atmosphere, &c. . . . . . The direct light of the sun has been estimated to be equal to that of 5,563 wax candles of moderate size, supposed to be placed at the distance of one foot from the object."

And in another place the same author adds—

"But to whatever cause the increasing heat of the earth, and the subterranean fires may ultimately be referred, it is certain that, except in some local instances, they have no sensible effect on the temperature of its surface. It may, therefore, be concluded that the heat of the earth, above the zone of uniform temperature, is entirely owing to the sun."*

"One of the causes," says Professor Whewell, "which determines the temperature of each climate is the effect of the sun's rays on the solid mass of the earth. The laws of this operation have been recently made out with considerable exactness, experimentally, by Leslie, and theoretically by Fourier, and other enquirers. . . . .

"The earth like all solid bodies transmits into its interior the impressions of heat which it receives at the surface; and throws off the superfluous heat from its surface into the surrounding space. . . . . . The parts of the earth near the equator are more heated by the sun than any other parts, &c. &c."†

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* By Mrs. Somerville. † Bridgewater Treatise, pp. 76, 77.

And again, a little further on, he says—

"The next circumstance which we shall notice as indicative of design in the arrangement of the material portions of the solar system is the position of the sun, the source of light and heat in the centre of the system."*

We must, in continuation, direct the attention to the first part of the *forty-seventh* Theorem:—"*That a comparison of the natural phenomena, in which the effects of light and heat are manifested, affords reason to infer the existence of a connexion so intimate between them as to warrant the belief of their identity.*"

Before proceeding to bring forward the *direct* evidences on which this Theorem is founded, reference is requested to the definitions given by Sir William Herschel, in a paper read before the Royal Society, May 15, 1800, of light and heat, whose manner of comportment in all essential circumstances are stated by him to be identical; and then let the only natural inference be drawn which can possibly be done by an unprejudiced mind, namely, *that no two substances or states of matter could comport themselves with such perfect similarity in such a variety of cases, and yet be essentially different.*

Sir John Herschel says—

"The laws of the radiation of heat have been studied with great attention, and have been found to present strong analogies with that of light in some points, and singular differences in others. Thus, the heat which accompanies the sun's rays, comports itself in all respects like light; being subject to similar laws of reflection, refraction, and even of polarization, as has been shown by Berard. Yet they are not identical with each other: Sir William Herschel having shown by decisive experiments, verified by those of Sir H. Englefield, that there exist in the solar beam both rays of heat which are not luminous, and rays of light which have no heating power."†

"Between light and heat," says Dr. Ure, "so intimate a relationship subsists, that they must be conceived as two modifications of the same fundamental agency."

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† Bridgewater Treatise, p. 169. † Nat. Philos. in Cab. Cyc. p. 314.

In another part of the same work he adds—

"Associated with light in the sun-beam, heat must also follow its theoretic fortunes."

In the Cabinet Cyclopædia it is said—

"That the principal properties of heat are so nearly identical with those of light, that the supposition that heat is obscure light is countenanced by strong probabilities."

Again—

"The calorific property which constantly accompanies the solar rays, as well as the rays proceeding from flame, would indicate that heat is a necessary concomitant or property of light. . . . . . The whole body of natural phenomena in which the effect of heat and light are concerned, demonstrate an intimate physical connexion between these agents." And, "if the identity of light and heat be admitted, then the question of the nature of heat is removed to that of light."

"In what has just been said," says Professor Whewell, "we have spoken of light only with respect to its power of illuminating objects, and conveying the impressions of them to the eyes. It possesses, however, beyond all doubt, many other qualities. Light is intimately connected with heat, as we see in the case of the sun and of flame; yet it is clear that light and heat are not precisely identical. Light is evidently connected, too, with galvanism and electricity; and, perhaps, through these, with magnetism. . . . . . It manifests, also, chemical action in various ways."*

Mr. Turner bears the fullest testimony in favour of the point we are now endeavouring to establish.

"From light," says he, "we cannot separate the recollection and companionship of heat. They are now found to be so generally existing in the latent or the active state wherever either is present, that they are thought to be modifications, or different conditions of the same element; when both these occur, we have fire. Fire is luminous heat, or heat in the state of light. The sun's light has the effect of both heat and light. . . . . . The Hebrew word used by Moses, "*aor*," expresses both light and fire."†

* Bridgewater Treatise, p. 138. † Turner's Sacred History.

In the "Connexion of the Sciences" the following corroborative testimony is given in favour of this point :—

"The progress of modern science, especially within the last five years, has been remarkable for a tendency to simplify the laws of nature, and to unite detached branches by general principles. In some cases identity has been proved where there appeared to be nothing in common, as in the electric and magnetic influences; in others, as that of light and heat, such analogies have been pointed out as to justify the expectation that they will ultimately be referred to the same agent; and in all there exists such a bond of union, that proficiency cannot be attained in any one without a knowledge of others." Again, ". . . . . Since the power of penetrating glass increases in proportion as the radiating caloric approaches the state of light, it seemed to indicate that the same principle takes the form of light or heat, according to the modification it receives, and that the hot rays are only invisible light; and light, luminous caloric." Further, "The probability of light and heat being modifications of the same principle, is not diminished by the calorific rays being unseen, for the condition of visibility or invisibility may only depend on the construction of our eyes, and not upon the nature of the agent which produces these sensations in us. . . . .

"As the action of matter, in so many cases, is the same on the whole assemblage of rays, visible and invisible, which constitute a solar beam, it is more than probable that the obscure, as well as the luminous part, is propagated by the undulations of an imponderable ether, and, consequently, comes under the same laws of analysis."

And, in conclusion from this writer—

"That light is visible heat seems highly probable; and although the evolution of light and heat during the passage of the electric fluid may be from the compression of the air, yet the development of electricity by heat, the influence of heat on magnetic bodies, and that of light on the vibrations of the compass, show an occult connexion between all these agents, which, probably, will one day be revealed. In the meantime it opens a noble field of experimental research to philosophers of the present, perhaps of future ages."*

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* Connexion of the Sciences.

We now require to examine the *forty-eighth* Theorem, and some of its accompanying evidences, namely, "*That by a concurring chain of deductive reasoning, drawn from the effects of the different heating powers of the component colours of the solar spectrum, when applied to substances reflecting various colours and degrees of heat; together with the corroborating testimony of the augmented heat of concentrated light, it is considered to be established beyond the possibility of doubt, that in these cases sunlight is the direct cause of heat.*"

"The calorific powers of the sun's rays," says the writer on heat in the Cabinet Cyclopædia, "may be exhibited in a very conspicuous manner by concentrating a large number of them into a small space, by means of a *burning glass*. . . . . . From experiments performed in this way by Count Rumford, it appears, however, that no change in the heating power of individual rays is produced by this means; but that the increased energy of their calorific action arises altogether from a great number of them being concentrated into a small space. . . . . . The heating power of the sun's rays, when collected by a burning glass, far exceeds the heat of a powerful furnace. A piece of gold placed in the focus of such a glass has not only been melted, but has been actually converted into vapour by Lavoisier."*

Sir David Brewster, in his Treatise on OPTICS, corroborates this opinion:—

"A combination of plane burning mirrors forms a powerful burning instrument; and it is highly probable that it was with such a combination that Archimedes destroyed the ships of Marsellas. . . . M. Peyrard conceives that with 590 glasses, about 20 inches in diameter, he could reduce a fleet to ashes at the distance of a quarter of a league; and with glasses of double that size at the distance of half a league. . . . . . The most celebrated concave mirrors used for burning were made by Mons. Villele, of Lyons, who executed five large ones. One of the best of them, which consisted of copper and tin, was very nearly four feet in diameter, and its focal length thirty-eight inches. It melted a piece of Pompey's pillar in fifty seconds, a silver sixpence in seven seconds and a half, a half-

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* Pages 349, 350.

penny in sixteen seconds, cast iron in the same time, slate in three seconds, and thin tile in four seconds."*

We have thus proved, by the concurring testimony of the most scientific writers of the age on the respective subjects under discussion, 1. That the sun is the source of the external light and heat received by the earth; 2. That light and heat are either identical or most intimately connected; 3. That the rays of sunlight cause heat; and 4. That heat causes expansion. We beg those several results may be carefully borne in mind, as they may be the means, hereafter, of enabling us to arrive at some important conclusions.

Let us now see what evidences we have for the support of the *fifty-first* Theorem, *That the phenomena arising from attraction and those from repulsion indicate the presence of two antagonistic forces acting at the same time on the particles of all bodies, and maintaining them in a state of equilibrium, which becomes more or less disturbed according as either of these forces preponderates.*

The Cabinet Cyclopædia remarks—

"We have seen that when heat is imparted to a body its dimensions have immediately increased; and it is found that this increase takes place equally through every part of the dimensions, so that the figure or shape of the body is preserved, every part being enlarged in the same degree. . . . . . In fact, they have driven each other to a greater distance asunder, and a repulsive force has, consequently, been called into action. On the other hand, if heat be abstracted from a body, its dimensions uniformly contract, its figure being preserved as before, and the diminution of size being equally produced throughout its whole volume. The component particles, in this case, therefore, approach each other equally throughout the whole volume of the body; in other words they are drawn together, and an attractive force is brought into action. . . . . These phenomena indicate the presence of two antagonistic forces, acting at the same time on the constitutional particles, and suspending them in equilibrium; namely, the *repulsive* agent, determined by the presence of heat, and increased in its energy by the increased application of the physical principle; and the *attractive* force, with

* Optics, Cab. Cyc. p. 314.

which the particles are naturally condensed, and by which they always have a tendency to cohere in solid masses. So long as the energy of the cohesive principle exceeds the power of the repulsive force produced by heat, the body will remain in a solid state; but, by the continued application of heat, the energy of the repulsive principle being increased, and the particles continually separated, these two powers will at length be brought nearly to the state of equilibrium."

And again—

"If there were no external source of heat, the consequences would be that the earth, by constantly dismissing heat by radiation into the surrounding space, would be gradually cooled, and the temperature of all objects would fall indefinitely. Liquids would be converted into solids, and gases into liquids, and subsequently into solids."*

"All bodies," says another writer, "consist of an assemblage of material particles, held in equilibrio by a cohesive force which tends to unite them; and also by a repulsive force, probably caloric, the principle of heat which tends to separate them. The intensity of these forces decreases rapidly as the distance between the particles augments, and becomes altogether insensible as soon as that distance has occupied a sensible magnitude. It is evident that the density of substances will depend upon the ratio which the opposing forces of cohesion and repulsion bear to one another."†

"We learn," according to Dr. Ure, "by scientific research, that each particular form depends on the relation between two opposite and contending powers—the attractive and repulsive. When the former power predominates, solidity prevails; when the latter, gasity, or the aerial state: and when the two, or nearly balanced, the liquid condition results.

"The attractive force is that which, under various modifications, gives origin to cohesion, tenacity, hardness, crystallization, and gravitation. Had *it* reigned alone in the terrestrial system everything would have been condensed into a motionless mass, in which water and air would have been fixed as the solid rock. This, therefore, is the natural condition into which the attractive particles of matter

* Heat, in Cab. Cyc. pp. 8, 169, 177, et seq.

† Connexion of the Sciences, by Mrs. Somerville, pp. 117, 243, et seq.

spontaneously tend to come, and at which they do arrive, unless counteracted by the divellent force called caloric or heat."*

And, lastly, on this subject we ascertain from Mr. Donovan,

"That it may be received as a general law, which, however, is not without exception, that the effect of cold on all bodies is to lessen their bulk, and to increase their specific gravity. Conversely, it might easily be anticipated that, by adding heat, the repulsion of the material parts would be increased, the bulk would be augmented, and the specific gravity diminished; this, accordingly, is found by experiment to be the case; and the law applies to matter, whether in the solid, liquid, or gaseous state."†

This, therefore, is another, and an important step in the direct progress of our argument. We formerly came to the conclusion that light and heat cause expansion. By this, we perceive that the expansive influence occasioned by light and heat is the direct antagonist to attraction; for it is asserted, "that were this principle of expansion not present, mutual approximation, crystallization, solidification, in short attraction, would be the natural and infallible consequences." We also have been made aware that heat and light may be considered concomitants. Being so, and, at the same time, the cause of expansion, it follows that their absence would be equivalent to the absence of the expansive principle. But the absence of light is darkness, and, as we have just made out, the absence, also, of the expansive principle; while this, in turn, *is equal to the presence of the attractive principle.* Consequently, when this reasoning is applied to Scripture, it warrants us to conclude, that the words which state that "*darkness* was upon the face of the deep,"‡ imply, as determinately, that *attraction* was "on the face of the deep."§

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* Dr. Ure's Chemical Dictionary. † Chemistry, Cab. Cyc. p. 44.

‡ Gen. i. 2.

§ Of this we have lately had a remarkable corroboration. On mentioning to a Hebrew philologist, during the course of conversation, the meaning we attach to the word "darkness," which occurs in this part of Scripture, and explaining how we arrived at that conclusion, he said that it had a peculiar signification which he could not very closely interpret, but the nearest

In continuation, we have, if possible, to determine the true import of the expression in the original, which the translators have rendered "deep," and, afterwards, to enquire whether scientific writers concur in considering that attraction extends throughout space, and pervades all matter.

With reference to the first of these points we have, fortunately, the following very apposite remarks in one of the Northern Reviews :—

"Of the earth (referring to the 2nd verse of Genesis), it is said that it was "*thohu*," and "*bohu*;" of the "*thehom*," that there was darkness on its aspect; and of the waters, that they were subjected to the vital energy of the Spirit of God. Now the *thehom* here mentioned seems to be used in a wider sense than as an appellation of the deep sea, or the bottomless place; for it is separately distinguished from the waters. It probably has here a more primitive meaning than that which is implied in its etymological relation to *thohu*, namely, a boundless place, and is used to denote *space*, that which is boundless, not in *one*, but in all its dimensions, not the *deep*, but the *vast*."*

This philological explanation appears closely to agree with the opinion of astronomers. Sir John F. Herschel, in referring to Newton's law of gravitation, says—

"Every particle of matter in the universe attracts every other particle with a force directly proportioned to the mass of the attracting particle, and inversely to the square of the distance between them."

And again—

"It is in consequence of the *mutual* gravitation of all the several parts of matter, which the Newtonian law supposes, that the earth and moon, while in the act of revolving, monthly, in their mutual

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is *that where it was paramount nothing could progress*, from a *restraining* or *negative* influence which it was employed to signify; and cited, as an illustration, the word rendered "withheld," in the 2nd verse of the xxxth chapter of the same book, the word used in the original being the same as that in the 2nd verse of the 1st chapter, and with the intention of conveying precisely the same meaning.

* Presbyterian Review on Mr. Fairholme's Geology.

orbits about their common centre of gravity, yet continue to circulate without parting company in a greater annual orbit round the sun."*

In the *Connexion of the Sciences* it is stated—

"The distance of the fixed stars is too great to admit of their exhibiting a sensible disc; but in all probability they are spherical, and must certainly be so if gravitation pervades all space, which it may be presumed to do, since Sir John Herschel has shown that it extends to the binary stars."†

And, in conclusion on this point, we have the forcible evidence of a recent writer, who, when describing the binary stars, says—

"One star moves round another (or, more properly, each round their common centre of gravity), in an elliptic curve; *precisely the curve which is described by the earth and other planets in their revolutions around the sun.* Uniformity of this sort is exceedingly remarkable; it points to *some common cause;* in other words, to the LAW OF GRAVITATION, which the nature of this curve enabled Newton to detect as the first principle of planetary order. Gravity has often been surmised to be universal; at all events we have now stretched it beyond the limits of the most eccentric comet into the distant intervals of space; whilst every extension of its known efficacy manifestly increases, in accelerating ratio, the probability that it is a fundamental law of matter."‡

We have thus carefully and enquiringly brought our present investigation, by two distinct routes, to a converging point, where we find, that the *darkness* mentioned in Scripture, besides its more popular meaning as the *opposite of light*, has a scientific and more recondite signification, and one which leaves no doubt upon our minds that it was meant to imply *attraction*, or an influence which, were it permitted to operate exclusively, would so grasp all materialism as to reduce it into one solid motionless mass of inertia. And having thus satisfactorily identified the *darkness* of Scripture with the *attraction*

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* Astronomy, Cab. Cyc.

† By Mrs. Somerville.

‡ Architecture of the Heavens, pp. 92, 93.

of science, we have continued our enquiries from sources connected with the latter, until we have proved that *attraction* is an all-pervading principle, or, as Newton's followers express themselves, "the first principle of planetary order;" and equalled in ubiquity only by *light;* which may, therefore, with equal propriety, be styled the *second* "principle of planetary order"—a result which the tenor of our recent enquiries, respecting this subtile fluid, authorised us fully to anticipate.

SECTION V.

INTRODUCTION OF THE LIGHT; THE CONSEQUENT PROTOROTATION OF THE EARTH; AND ITS DYNAMICAL RESULTS.

CHAPTER XIV.

Explanation as to the possibility of the Earth and other planets, with their respective satellites having, in accordance with astronomical laws, revolved in space around the common centre of the system, long previous to the illumination of the sun. Further proofs that Darkness, in the language of Genesis, implies Attraction. Consequence of this fact upon the development of our Theory. Existence of the primeval Light *before* it was divided from the Darkness, and the important bearing of this truth on the subject under discussion. A few concluding observations on the subjects treated of in this chapter.

Having reached this convenient resting place, we shall, on commencing another chapter, avail ourselves of the juncture thus afforded, and of which we have long been desirous, to say a few words in explanation of the position assumed from the first, on the faith of its being unquestioned, although at variance with most of our pre-conceived opinions. We allude to the fundamental doctrine of this Theory, that the earth, and other planets—in virtue of the same laws which now govern their orbital motions—revolved around the sun; the satellites around their primaries, and the whole around the common centre of gravity of the system, for *ages before the sun was illumined;* for it may be supposed, by those who have not enquired into these subjects, that the solar system could not have existed under such circumstances.

In a subsequent part of this work we shall have occasion to prove, in a more formal manner, that the planetary *orbital* mo-

tions in space, are perfectly independent of, and can exist with or without *rotatory* motion. Meanwhile, to convince our readers, that the solar system might exist, and perform all its orbital functions, although the sun should be again reduced to what it assuredly once was, for a long but indefinite period, AN OPAQUE MASS; and darkness should be again restored to its ancient dominion over the face of the deep—if the assertion made, to that effect, in Scripture be not deemed sufficient—we offer the the following opinions of men whose word should dispel all remaining doubts:—

"Let it be granted," says Professor Whewell, when deducing evidences of design from the sun being in the centre, "that the law of gravitation is established, and that we have a large mass, with others much smaller, in its comparative vicinity. The small bodies may then move round the larger, but this will do nothing towards making it a *sun* to them. Their motions might take place, the whole system remaining still utterly dark and cold, without either day or summer. In order that we may have something more than this blank and dead assemblage of moving clods, the machine must be lighted up and warmed.

"Now this lighting and warming by a central sun are something added to the mere mechanical arrangements of the universe. There is no apparent reason why the largest mass of gravitating matter should diffuse inexhaustible supplies of light and heat in all directions, while the other masses are merely passive, with respect to such influences. There is no obvious connexion between mass and luminousness, or temperature. No one, probably, will contend that the materials of our system are necessarily luminous or hot. . . . .

"The sun might become, we will suppose, the centre of the motions of the planets by mere mechanical causes; but what caused the centre of their motions to be also the source of those vivifying influences? Allowing that no interposition was requisite to regulate the revolutions of the system, yet, observe what a peculiar arrangement in other respects was necessary, in order that these revolutions might produce days and seasons! The machine will move of itself, we may grant; but who constructed the machine so that its movements might answer the purposes of life? . . . . .

"This argument is urged with greater force by Newton himself. In his first letter to Bentley, he allows that matter might form itself

into masses by the force of attraction. 'And thus,' he says, 'might the sun and fixed stars be formed, supposing the matter were of a lucid nature. But how the matter should divide itself into two sorts, one luminous, the other opaque, he confesses he knows not.'"*

There appears, therefore, to be nothing wanting to convince an unprejudiced mind; that *darkness*, in Scriptural language, signifies *attraction;* and that according to the Mosaic account it "was upon the face of the deep," implying space in all its vastness and extent; and consequently that it pervaded our system as a part of space.

For our own part, we at once adopt these terms in the acceptation here given; and until they can be proved to have a different meaning we shall so apply them in all our future reasoning.

Yet, we desire not to be misunderstood; for we are perfectly aware there are minds capable of resisting this mode of reasoning; and, indeed, every mode of reasoning short of tangible evidences. For the conviction of such, we regret to say, that neither the nature of the subject, nor the present state of science, will admit of these *direct* appeals being made to their senses, although presently we shall have occasion to show, *that during a long but indefinite period, there existed a state of matters on the face of our planet, to which light, as it now exists, so far from being serviceable, would actually have been inimical;* and consequently could not, in accordance with the wisdom of the Supreme Being, have possibly existed. Besides, by denying or refusing to accede to the supposition that *darkness* is the scriptural expression for *attraction*, it would imply, that the inspired historian has omitted to mention a principle which is known, and confessed to have pervaded the whole universe! A conclusion alike inconsistent with our belief of the wisdom and prescience of that Omnipotent Being who dictated the divine record, as well as with all our experience regarding it; for no other circumstance, no, not even the most

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* Bridgewater Treatise, pp. 169—171. The remainder of this letter is not given, from being irrelevant to our present purpose, which is merely to prove, as we have seen they both admit, *that the system could have existed though the sun had not been illumined.*—Author.

minute, is overlooked when such is necessary to render the announcement complete. But it is not alone in this part of Scripture, as we have already been made aware, that darkness is mentioned as equivalent to attraction. We have the authority of the Almighty himself—it is so applied in several passages—and when speaking from the whirlwind to his patient and afflicted servant, he asks him in the sublime words which suited such an occasion, "Or who shut up the sea with doors when it brake forth as if it had issued out of the womb? When I made the cloud the garment thereof, and *thick darkness* a swaddling-band for it,"* or in other words, before I thereby restrained it.

Taking, therefore, all these things into consideration, whether is it not more consistent with candour, or even with reason, to consider that the *darkness* mentioned by the Divine historian is the expression for *attraction*, when such well-grounded evidence can be adduced in favour of this reading? or, in the face of these proofs, and the concurring testimony of analogy, to persist in considering the words of inspiration to be defective?

The following considerations may, perhaps, serve to confirm our convictions with regard to the Scriptural meaning of the word "*darkness*." Admitting, for a moment, that it does signify attraction—and we do not see how it can well be denied—then we have the following. *The ultimate end of attraction is rest or inertia;* for we cannot conceive of matter tending, as it would do under the unrestrained influence of attraction, to a centre, without associating in our minds *the idea of its tending ultimately to rest.* But if attraction be *rest*, *inertia*, or *immovability*, then it follows that all *motion* must be the antagonist of attraction; the very motion that matter has in tending to a centre being nothing save the visible effects of attraction when it is overcoming repulsion.

This view of the subject enables us to perceive more clearly the wisdom of the announcement which immediately follows the words already quoted: "The Spirit of God moved upon the face of the waters."

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* Job xxxviii. 8, 9.

It certainly does not become us, as finite, imperfect beings, to enquire into the nature of the movement here indicated; or the manner in which it was communicated to "the waters" by the life-giving influence of the Spirit of God; all we have to do is to believe, *because it is so written.* We confess our thankfulness that our minds are so constituted as to be enabled clearly to recognise that such is in strict accordance with the wisdom and the other attributes of the Deity; and to believe most firmly, in unison therewith, that the counteracting influence to attraction, whose effects are still appreciable in the works of the Creator during the period when "darkness was upon the face of the deep," was communicated to matter by immediate and Divine influence; and that it was *motion* which was then communicated. Not only because it is thus recorded in Scripture, but because it is confirmed by reflection, and the use of the reasoning faculties. For, as by the law of inertia, "matter can neither spontaneously create nor destroy motion in itself,"* so, consequently, whatever vibratory motion existed in the circumfluent, atmosphereless water of the earth *before* the formation of the light, must have been derived from a supernatural and immaterial source.

Those only who have felt the intense anxiety of mind arising from the contemplation of such subjects—which require to be traced out in the illimitable field in which they exist, and the fear which is entertained in doing so, of blending or weakening truth by conjecture—are capable of appreciating the comfort of finding spots of such secure foundation as those we have just elicited, and which, springing from opposite sources, science and religion, afford a firm footing amid all that is obscure and dubious around.

Science has rendered incalculable service by tracing so clearly the boundary line of the capability of matter, and frankly declaring "that it is unable to engender spontaneous motion in itself, or to destroy it when once it is originated by any external cause." Whilst, with an assurance such as this, exhibiting the inherent limits of matter, it is satisfactory

* Vide the sixty-seventh Theorem.

to be informed by the Creator himself that he supplied that which was wanting; and that what matter could not do was done for it by Divine power; for "the Spirit of God moved upon the face of the waters."

Our own investigations, likewise, seem to strengthen the reliance which we feel disposed to place in the truthfulness of this recondite portion of Scripture. For, it may be remembered, that we took considerable pains to draw a broad line of distinction between the two consecutive creative acts; that of *forming the light complete in itself*, and that of *impressing a peculiar state or condition upon it.* The former of these we considered as having permeated all materialism with an ethereal quiescent fluid. The latter communicated to that elastic, tenuous expansion, a vibratory movement of almost inconceivable rapidity, and in a direction which should cause it to act as the antagonist of attraction. And it is when we distinguish most clearly *between* the perfection of the constitutional nature of this all-pervading fluid and its impressed condition, and also keep before our minds that, at the period alluded to in the second verse of Genesis, it was *not* in existence, that we shall be most fully impressed with a conviction of the correctness and truth of the announcement therein made, "that the Spirit of God moved on the face of the waters." All matter is *now* pervaded with the ethereal fluid to which we have so frequently alluded, and through its movements or vibrations light and heat are communicated, by certain determinate laws, to the former. "In the beginning," however, the whole material universe was surrounded by aqueous envelopes; this, as regards the earth, we have made clearly manifest in the three preceding sections, wherein we have shown, that the existences alike of the animal and vegetable kingdoms tenanted the bottom of the primitive water; and that the stratified rocky masses were deposited from an ubiquous ocean which held their elements in suspension; and, consequently, that the whole sphere was circumbounded by water. We have every reason for supposing that *then* there was no existent state of matter of greater tenuity than *water.* To this, therefore, the requisite vibratory motion was commu-

nicated by the only Being who could impart it, or who could determine the degree of warmth which was necessary to maintain it, and the material portion beneath, in the state best adapted for sustaining and fostering the myriads of living creatures and of plants which were destined to dwell beneath, and there to work out his sovereign will and pleasure.

The great difference between the medium which received and communicated the sensation of heat in that era of the earth's history, and the ethereal medium which now performs the same office, may, possibly, account for the additional density which, in general, is found, by the exuviæ, to have prevailed in the external coverings of zoophyta, plants, and animals of the ancient world; and to which reference has been made in the *hundred and thirty-seventh* Theorem. To this we shall merely allude, leaving it to others, and to a more advanced condition of science, to elucidate the subject more thoroughly; but we would take occasion, even now, to caution whoever engages in this new and ample field of investigation, to beware of confounding in any degree the *power* and the *free will* of God with the *designs* which it pleased him then to have in view. It was not the *want* of power which withheld the light from existing as now constituted for so many ages, but because another, and a more direct, agency was essential. Neither was the arm of the Omnipotent less capable of having "stretched out the firmament like a curtain" from everlasting; but because he chose to place the whole material universe in vacuo, and in that state to cause his multifarious organic instruments to produce that which would endure. Not air dissolving textures, but hard, stony, perdurable substances, which should remain, and, by layer after layer, encrust the mundane sphere, in preparation for the time, foreseen from all eternity, when by the rotation of the earth, they should start into life, as it were, and form themselves into continental chains and oceanic hollows, with all the variety of hill and dale, mountain and valley, which render the present earth so fitting an abode for those creatures which were in due time to be ushered in for the purpose of rendering him intellectual service, and for his own glory; and whose redemption from the Destroyer has

eventually distinguished this sphere, thus curiously and elaborately wrought, and has spread a halo over it by the light which is shed upon it from the Redeemer's crown!

We shall, as we have before said, leave the conception, namely, that the peculiarity in the external *media,* which the animals and plants of the non-rotating period interposed between themselves and the communicating medium of heat during that era, has an intimate connexion originating from a law common to both—to be matured by others; but, in the meantime, we take occasion to observe, that what we *have been enabled clearly to make out* respecting the working of the Creator "in the beginning," has opened up a fine vista into those remote periods of time, and has shown us, that although "darkness was upon the face of the deep," yet the Lord's ways have ever been persistent. That there has been an undeviating unity of plan from the first; that during the whole period shadowed forth by "the beginning," the law of progression, by repeated consecutive acts of creative energy, was the principal feature impressed upon matter. That it was, in fact, the development of the great plan of creation, traced from everlasting, and continued to be unfolded until the riches of a wisdom which is unsearchable was fully displayed, and God himself, with Divine complacency, could declare the whole to be "very good."

The following passages from some of the scientific writers of the day, seem to corroborate the views we have adopted of LIGHT and DARKNESS; while they more especially tend to confirm the idea of the identity of DARKNESS and ATTRACTION:—

"The luminous *ether*, then," says Professor Whewell, "if we so call the medium in which light is propagated, must possess many other properties besides these mechanical ones on which the illuminating power depends. It must not be merely like a fluid poured into the vacant spaces and interstices of the material world, and exercising no action on objects; it must affect the physical, chemical, and vital powers of what it touches. It must be a great and active agent in the work of the universe, as well as an active reporter of what is done by other agents. It must possess a number of complex and refined contrivances and adjustments which we cannot

analyse, bearing upon plants and chemical compounds, and the imponderable agents ; as well as those laws which we conceive that we have analysed, by which it is the vehicle of illumination and vision. . . . . . All analogy leads us to suppose, that if we knew as much of the constitution of the luminiferous ether as we know of the constitution of the atmosphere, we should find it a machine as complex and artificial, as skilfully and admirably constructed.

" The mere fact, however, that there is such an *ether*, and that it has properties related to other agents in the way we have suggested, is well calculated to extend our views of the structure of the universe, and of the resources, if we may so speak, of the power by which it was arranged. The solid and fluid of the earth are the most obvious to our senses ; over this, and in its cavities, is poured an invariable fluid, the air, by which warmth and life are diffused and fostered, and by which men communicate with men ; over and through this again, and reaching, so far as we know, to the utmost bounds of the universe, is spread another most subtile and attenuated fluid, which, by the play of another set of agents, aids the energies of nature, and which, filling all parts of space, is a means of communication with other planets, and other systems.*

" It appears highly probable," says Professor Buckland, " from recent discoveries, that light is not a material substance, but only an effect of undulations of *ether;* that this infinitely subtile and elastic ether, *pervades* all space, and even the interior of all bodies ; so long as it remains at rest there is total darkness ; when it is put into a peculiar state of vibration, the sensation of light is produced : this vibration may be excited by various causes ; *e. g.* by the sun, by the stars, by electricity, combustion, &c. If, then, light be not a substance, but only a series of vibrations of ether, *i. e.* an effect produced on a subtile fluid by the excitement of one, or many extraneous causes, it can be hardly said, nor is it said in Gen. i. 3, to have been *created*, though it may be literally said to be called into action."†

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* Bridgewater Treatise, pp. 138—140.

† Idem, vol. i. p. 32. We must here remind our readers that whatever interpretation may be given to the words of the original, the light, when willed into existence, was pronounced to be *good*, *before* it was divided from the darkness, and consequently was "complete and whole lacking nothing," and, as such, was a *perfect formation* independently altogether of the division which afterwards, by the command of God, took place between it and the darkness.—AUTHOR.

In a previous part of this section we endeavoured, and we think succeeded in proving that, in Scriptural language, *darkness* signifies *attraction*, and that attraction propends by its inherent nature to *immobility*, *inertia*, or *rest*. Now, in the passage just quoted, Dr. Buckland, supported by numerous respectable authorities, considers darkness to be "*the ethereal medium at rest*."

The conclusion that such might have been the case, nay even that for a brief period it *actually was* the case, we had arrived at, but by a different route, and without being aware of the concurrence of this learned writer in its favour. But it must be remembered, that this "state of rest of the ethereal medium," which is called light in Scripture, was comparatively of *mere momentary duration*. Its *formation* and its being *put into motion* having been two consecutive acts of creative energy performed *on the same day*. Therefore, the evidence, in this instance, of Dr. Buckland and others, goes merely to prove, that the *existence* of the ethereal medium, and its *movement* are *separate* and *distinct*, and that the one may exist altogether irrespective of the other, which is tantamount to the admission that the motion which it did receive was communicated to it by some power or influence exterior to and above itself.

The other attendant opinion which we entertain, that during the period of non-rotation, or that which is signified by "the beginning," the "ethereal medium" did not exist in its perfected condition, is entirely a distinct conception, and rests alone upon the authority of Scripture; for, with every reliance on this, we believe that at the time when it is said "darkness was on the face of the deep," it is not meant to imply, that this all-pervading element was then stretched out, although it had not been put into motion, *in the perfect sense of that term*, but that *as yet there was no ethereal medium at all*, although we believe, as firmly on the other hand, that the materials of the ethereal fluid were created during the period called the beginning, in common with the materials of every thing else pertaining to our system. But its existence *then*, in its perfect state, was not in accordance with the degree of development which the decrees of God had at that period undergone.

Whenever these were sufficiently matured, "God spake the word," and there was light; after which it was immediately put into vivid motion and requisition; and became the active instrument, in the hands of the Creator, to complete many of the subsequent works of that eventful week.

We believe, also, that it would have been alike consistent with truth, whether the words of the original had been rendered into our language, "*attraction* was on the face of the deep," or "*darkness* was on the face of the deep:" while we consider that the movement mentioned in the clause immediately following, "and the Spirit of God moved on the face of the *waters*," did impart, in due proportion, the counteracting principle (that is, to *attraction*) according as the progressive state of the creation then required, or could receive it. The *light*, as it is now constituted, and the effects which its formation produced, would have been positively injurious to the operations *then progressively taking place towards a state of perfection and fixity, which renders the light, as we now enjoy it, necessary for its permanency and well being.*

It is scarcely possible to conceive, that while the creation was passing through innumerable stages of progression, never stationary at any one point in the scale, nor indeed could be until it was finished, and pronounced to be "good," light upon fixed and permanent principles, whereby a certain quantity only is imparted daily,* should have been, at all, adapted to it. *A progressive state, with a constant determinate fostering medium, is not, cannot be considered consistent with the wisdom of the Creator.* This self obvious truth being conceded, it follows that the spirit of him who was forming and preparing the whole *for a subsequent state of permanency,* which it was to attain at a future period, could alone have supplied the proper and requisite portions of warmth, or heat, or motion, or counteracting principle to gravitation, during all the successive stages of its progression. For who could have known or divined the particular point to which the whole was tending—to which all the conjoint means were to concentrate in perfection, except the Spirit of the Creator? "For the Spirit

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* See the 2nd Theorem.

searcheth all things, yea, the deep things of God. For what man knoweth the things of a man save the spirit of man which is in him? Even so the things of God knoweth no man but the Spirit of God."*

This is a conclusion which we have been constrained to adopt, as the legitimate result of the attendant conditions, *whenever we admit of a progressive state of the Creation.* We must either believe that, in a state of progression, the supply of heat would be varied, or doubt that the sun now yields a fixed and determinate quantity of that enlivening and all-pervading medium. But this latter point being established, it enables us to come to the final conclusion, that, whatever may be thought respecting the ethereal medium of modern philosophy, this we know—and, fortunately, it is sufficient for our future purpose—that the "*darkness*" of Scripture does mean "*attraction,*" and that the movement of "the Spirit of God on the face of the waters," communicated that proportion of the countervailing principle which was most conducive to the well-being of creation, as it passed through the successive stages of progression, until it reached its present perfection. These truths we consider to have been sufficiently established to admit of their being applied throughout the remainder of this treatise, in the course of which we shall be able to adduce evidences of a more tangible, and purely geological description, to contribute in establishing the fact of the NON-ROTATION of the EARTH, and in corroboration of what we have all along so earnestly been contending for.

The part which we have gone through of this branch of our general evidences may be considered as purely intellectual, having had exclusively to do with abstract principles and mental symbols; and may, with propriety, be compared to that period of Columbus's undertaking when he found himself under the necessity of explaining those correct, but abstract, conclusions which so clearly revealed to his mind—but to his alone—the existence of the great Western World. The section we are about to enter upon may, not inaptly, be compared with the labours of that discoverer when engaged in

* 1 Corinthians, ii. 10, 11.

proving the soundness of his conclusions by the choicest of all tests, their application to practice. It may be that our expedition through this hitherto unexplored region, has, like his, been beset with difficulties of so disheartening a character to those who, in every respect, are not like minded, or so high in hope as ourselves, that they may wish to turn back, longing for the safe and care-free haven from whence they set out.

But should there be any such, we have to reanimate and encourage them by our determination on the one hand, that whether they part company with our bold little bark in mid-passage or not, we design, with God's assistance and the hope he has given us, to prosecute our adventurous voyage ; and, by the assurance, on the other, that if they will be of good cheer for a little longer, while passing through these shoreless regions of thought, we shall have the satisfaction of landing them in safety on the *terra firma* of geological proof, as evident, tangible, and solid, as are the objects with which that science usually is conversant.

SECTION V.

INTRODUCTION OF THE LIGHT; THE CONSEQUENT PROTOROTATION OF THE EARTH; AND ITS DYNAMICAL RESULTS.

CHAPTER XV.

Some of the immediate effects of the Light with reference to its dynamical power. During the first three days it was not concentrated around the Sun, consequently different from the light at present received. The expansive influence of Light and Heat act in opposition to Attraction. The repulsive power of Light investigated and established. The introduction of Light into the material universe equal to the introduction of a new *force*. Laws of force and motion investigated with reference to this event. Expansion being a *force*, and the bodies of the solar system being incapable of expanding beyond their prescribed orbits, they must have expended or met this new force by *rotation around their respective axis*—show that the Earth has a double movement in space, and that the diurnal rotation is perfectly independent of the periodical revolution around the Sun. Scriptural corroborations of these important conclusions. Sunlight the residue of the primary light. Evidences to prove the enormous amount of Heat and Light which come from the Sun, and the application of this to our general argument.

In prosecution of what we resolved upon at the close of the last chapter, and relying on the hopes we have ventured to express, we shall endeavour in continuation, to estimate the consequences which resulted to the earth by the introduction of the Light into the material universe, when the plan of creation was so far matured as to admit of this new agent—indeed to require it—in order to put the earth in motion; for without the sudden impetus of the primary light our planet would have continued to have slumbered on, unknown to rotatory motion, around the unillumined sun, enveloped in its stony crust of horizontal concentric strata, surmounted by an atmosphereless ocean, but entirely "without form and void."

Before we proceed, however, to trace the momentous consequences which sprang from the introduction of the light, and its division from the darkness, it may be as well to take a *connected* view of the portion of Scripture which has reference to it. The following are the words of inspiration:—"And God said, Let there be light: and there was light. And God saw the light, that it was good: and God divided the light from the darkness. And God called the light day, and the darkness he called night. And the evening and the morning were the first day."*

In contemplating these simple and sublime words, several important truths present themselves to our mind, some of which we have already noticed and insisted upon: First, That in the sacred record no *locality* is assigned to the light when it was formed; nor indeed during the first three days of the Mosaic week. Next, That from the words of approbation, "it was good," having been applied by God to the light immediately after its formation, and *before* it "was divided" by him "from the darkness," we are authorised to conclude, as we have so repeatedly done, that there was a time, however evanescent, when, though perfect in its innate nature, it was *not* divided from the darkness. That in this state it produced no effects, all those emanating from it having taken place *after it was "divided from the darkness."* And lastly, That by being thus divided, the light received directly, from the hand of God, the impetus of motion, which, being material, it could not have impressed upon itself.

As the first of those truths will more especially occupy our attention in a subsequent section, we shall, at present, merely add to what we have said regarding it, that in whatever state or condition the light may have been during the first three days of the Mosaic week, *it could not possibly have been situated either in or around the sun,* because, from that, or indeed any other concentrated position, it could not have produced the effects which emanated from it during those three important days; nor had such been the case would it *afterwards*

* Genesis i. 3—5. Also p. 8 of this work, with the confirmatory quotations from Scripture.

have been stated *that it was concentrated around the sun*, as it has been recorded in Scripture. In the confidence of making these assertions sufficiently obvious in the sequel, we shall, meanwhile, go on to consider the stupendous results which proceeded from the *formation of the light, and its division from the darkness.*

To appreciate fully the importance of the announcement, *that* "*the light was divided from the darkness*," we must recur to what we endeavoured to substantiate at the commencement of this section, namely, that *darkness* is the Scriptural expression for *attraction;* and then learn from Sir John Herschel, the *direction* of that centripetal force.

> "The direction of attraction," that gentleman says, "at every point of the orbit of each planet *always passes through the sun.* No matter from what ultimate cause the power which is called gravitation originates, be it a virtue lodged in the sun as its receptacle, or be it a pressure from without, or the resultant of many pressures or solicitations of unknown fluids, magnetic or electric ethers, or impulses: still when finally brought under our contemplation, and summed up into a single resultant energy, its *direction* is, from every point on all sides towards the sun's centre."*

By combining these truths with the one under consideration, there results, that to "divide the light from the darkness," signifies, to impress upon it an opposite nature or tendency to that of darkness. But *darkness* is *attraction;* and, therefore, if attraction be a force propending towards or propelling matter *towards* the centre, light or heat must be a force propelling matter *from* the centre—a conclusion which perfectly accords with what has already been said, viz., that light and heat are so intimately connected, as to warrant the assumption of their identity;† that heat causes expansion;‡ that expansion is the antagonist of attraction;§ and, therefore, as before stated, if *attraction* acts in a direction from the circumference towards, and through, the centre, then *expansion*,

* Astronomy, in Cab. Cyc. p. 221, et seq.

† 47th Theorem.

‡ 50th Theorem.

§ 51st Theorem.

as its antagonist, must act in a contrary direction, or towards the circumference.

In corroboration of the justness of the view here adopted of these Scriptural expressions, we have to offer, that which equally applies to a similar, though subsequent, announcement, wherein it is said that "the water *under* the firmament was *divided* from the water *above* the firmament."

This, as we are prepared to show in its proper place, signifies, that the water *above* the firmament was caused to ascend in the atmosphere by being combined with the expansive principle, while that which was *under* the firmament, being less saturated with that principle, descends, to unite itself with the mass of water preserving its original state of liquidity; and thus, a perfect division is effected between these two states or conditions of water, in consequence of the one being impressed with a tendency to *ascend*, while the other takes a *contrary* direction, from a point which, for wise purposes, is itself variable. In like manner, it is conceived, that the division effected of the *Light* from the *Darkness*, implies a *divergency of motion:* for as motion is one of the most important conditions of matter, or means of producing change or modification in the material universe, too much care cannot be bestowed in investigating narrowly the primitive laws which impressed a permanency of character upon it; while, perhaps, no agent wielded by the wonder-working arm of the Omnipotent, was ever more available or more universally employed than light, the second general law of materialism; and which then, for the first time, was introduced, in its *appreciable* material state, into the works of the Creator; from whose own will it received the impulse of motion to which we have been alluding, and which it could not, from being material, have generated in itself—thus affording another testimony of the intimate knowledge of the laws of matter, which was communicated to the inspired writer, by him who alike dictated those remarkable announcements, and called the light into existence.

Assured, therefore, that during the first three days of the Mosaic week, the light, although it existed, was *not* concentrated around the sun; that consequently it was *not, could not,*

be the description of light which we now receive from that luminary. Convinced, that wherever it was during that intervening period, it was precisely where the plans of the Creator required that it should be; and satisfied that the important positions which we have taken up and proven, namely, its ubiquity; its perfection *before* it was put into motion; and that when put into motion it was impressed with a nature which made it the opponent of gravity—are sufficient to enable us to go on with our argument; we shall proceed to determine, the probable consequences of the introduction of the expansive principle of light into the material universe as it was then constituted; confining our investigations to those which would take place on our planet, revolving, without rotatory motion, round an *un*illumined sun, and constituted geologically, as at the conclusion of the last and commencement of the present chapters, we have supposed it to have been.

We shall begin this investigation by recapitulating the *sixty-eighth* Theorem:—"*That the molecules of bodies are not placed together merely in unrelated juxtaposition, but either cohere and resist separation, or mutually repel each other; while the mutual approach, by attraction of particles placed at a distance from each other, or their further separation by repulsion, are effects of the same class, both of which are termed* FORCE. *That, therefore, 'whatever produces or opposes the production of motion or pressure in matter is force;' in which sense it is the name or symbol for the unknown cause of a known effect. That* FORCE, *when manifested by the mutual approach or cohesion of bodies, is called* ATTRACTION; *separable into as many branches as it has distinct modes of displaying itself. But when* FORCE *is indicated by the re-motion of bodies from each other it is called repulsion or expansion.*"

Being convinced by this that repulsion is one of the two principal forces recognised, by mechanical writers, as governing materialism, we shall next proceed to examine some of the evidences regarding its intensity:—

"It is a general law," observes Mrs. Somerville, "that all bodies expand by heat and contract by cold. The expansive force of caloric has a constant tendency to overcome the attraction of

cohesion, and to separate the constituent particles of solids and fluids; by this separation the attraction of aggregation is more and more weakened, till, at last, it is entirely overcome, or even changed into repulsion. . . . . . By the continual addition of caloric, solids may be made to pass into liquids, and from liquids to the aeriform state, the dilatation increasing with the temperature; and every substance expands according to a law of its own."*

"The first and most common effect of heat," according to the Cabinet Cyclopædia, "is to increase the size of the body to which it is imparted. This effect is called dilatation or expansion: and the body so affected is said to expand, or be dilated. If heat be abstracted from a body, the contrary effect is produced, and the body contracts. These effects are produced in different degrees, and estimated by different methods, according as the bodies which suffer them are solids, liquids, or airs."†

"Caloric," says Dr. Ure, "is the agent to which the phenomena of heat and combustion are ascribed. This is hypothetically regarded as a fluid of inappreciable tenuity, whose particles are endowed with indefinite idio-repulsive powers, and which, by their distribution in various proportions among the particles of ponderable matter, modify cohesive attraction, giving birth to the three general forms of gaseous, liquid, and solid. . . . . . The force with which solids and liquids expand or contract by heat and cold is so prodigiously great as to overcome the strongest obstacles."‡

These evidences will have sufficed to convince any one of the enormous, the almost irresistible, power of *expansion.* This being in direct proportion to the *quantum* of light and heat, we have next to investigate the consequences of the introduction of so inconceivable an amount of the expansive influence into our system, the remainder of which, in its visible condition, is now concentrated around the sun; and in attempting this we fortunately need not, for the present, take into account either its primitive locality or direction, *but merely its expanding influence.*

In doing this we shall enter upon what may be considered the test of those principles which, from the commencement,

* Connection of the Sciences, p. 234. † Heat, in Cab. Cyc. p. 8.
‡ Chemical Dictionary, pp. 253, 257.

we have laid down for our guidance; and it is now, therefore, that we must rely upon them. If they have the validity which we consider they possess, they will carry us through. Our progress may be slow and beset by many difficulties, but our confidence, amidst them all, in the announcements of Scripture should be constant and unfaltering, for, in many instances, we shall have them alone to lean upon for safety, and to assist us in our onward progress through spaces where science has never been. As the compass directs the mariner with unerring certainty through the boundlessness of an unknown and shoreless sea, so, we trust, will these principles and a thorough reliance upon the words of the Divine Record, guide us through these untrodden paths of the mental voyage which we are now about to undertake.

It is a source of great encouragement to consider that what they offer for our guidance is no fiction, no flight of the imagination, but clear and consistent realities; many of them, it is true, intellectually perceived, and relied on by faith alone, but not the less real on that account. In being led by them, we shall be, in fact, attempting to do what ought to have been done long ago; to call upon those engaged in scientific discussions to embody in their researches the announcements of Scripture with as much confidence and as willingly as they would the deductions resulting from an oft-repeated scientific experiment. It is our earnest desire that the Creator should be looked upon as a veritable Creator, as a Being mighty in power, and infinite in all his attributes of holiness, justice, goodness, wisdom, and truth; but still the Being thus perfect who actually made and fashioned all those objects about which science is so conversant; and who, of his own good pleasure, selected, trained, and prepared a man for the express purpose of revealing by and through him an exact account of what took place during the creation—not in figurative language, which may be taken in any sense best suited to the mind of each interpreter, but in the very words which stamped a form upon matter; which are, in fact, nature's constitutional code, and like its Divine author in every respect faithful, true, and endurable.

In asserting these clear and decisive opinions, we entertain

no desire to draw aside a single fold of the veil which has been thrown over what does not pertain to us; although we would wish to cultivate in ourselves and impart to others that regulated strength of mind which may enable us to look with admiration on that display of wisdom and power by the Creator which is made so manifest by the words of revelation, and reflected with so much truthfulness by the light of nature from his works. We are aware that there are minds, as there are eyes, which cannot sustain the brilliancy of unsubdued light; and few so eagle-eyed as to be able to gaze with impunity upon the splendour of the meridian sun in all its fulness. Nevertheless, none have a right to doubt its existence, or to underrate its importance, far less to deny the reality of those material objects which its rays make visible to them. And so with us. Although we dare not, with impunity, look into "the hidden things which belong to God," we are taught, on the other hand, not to undervalue those subdued manifestations which, through his inspired historian, he has been pleased to send forth of the full glory of his power and wisdom within; or to deny the existence of those intellectual truths which we are made to perceive by the light which has been shed upon them from on high; while we are shut up to believe them by faith alone in his word.* Therefore, when it is announced that *before* the light was formed, "the Spirit of God moved upon the face of the waters," however incomprehensible this may appear to the unpractised mind, we have only to believe that such was the case; and that, when there was yet no ethereal fluid to receive and propagate the light, it pleased God, immediately of himself, to communicate such a motion to the water as should be the fitting equivalent, and that which alone the then condition of the material universe rendered most conducive.

Why it was so, and wherefore it pleased the Omnipotent to place the whole material universe under water, to work out the plan of Creation in vacuo, we shall never, in all likelihood,

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* "By faith we understand that the worlds were framed by the word of God; so that things which are seen were not made of things which do appear." Hebrews ix. 3.

be able fully to comprehend. We can only obtain here and there a faint glimpse of some of the leading occurrences in the progressive process itself, while we recognise in what we can perceive the most perfect harmony of design; assuming, as we faithfully do, that the announcements made to us are perfectly correct, both as regards the events and the order of sequence in which they took place.

For instance: with respect to the atmosphere, we can make out that before it was "stretched forth as a curtain," one of the essential elements in it, which is destined for the safety of pulmonic, air-breathing animals, was slowly and gradually produced at the bottom of the ocean by apulmonic creatures, whose gaseous exhalations after their death assisted to purify the water, as they ascended by their specific levity through it.

And again: we think we can recognise the WISDOM of there being no ethereal fluid to occupy the space between orb and orb, and system and system, while as yet there was not an eye in the whole creation of greater sensibility than that of a crystallized cone of innumerable brilliant fascets, admirably adapted, no doubt, to the medium which then communicated sensation; but resembling more the sparkling product of the lapidary's skill than the sensitive light-perceiving cornea of the present races of creatures: and when it is considered that all organic existences were then immersed in water, and received from this comparatively dense medium those sensations of warmth which were found requisite to be imparted to them, while they could not have been benefitted, in the slightest degree, by the present space-pervading ethereal fluid—even had it been created—we shall no longer withhold our cordial conviction of the WISDOM which ordained, that the motion then required should be communicated to the external water of the universe; or of the FAITHFULNESS of the Record which asserts that such was the case, and that it was the work of the Holy Spirit to impart the requisite motion. We have repeatedly declared, that we cannot, we *may* not, take upon ourselves to enquire *why* the laws which then governed materialism were so ordained; but so they were. While it is fortunate that, although thus shut up to believe without being able to explain, it does not in any way interfere with the prose-

cution of our general argument, which can be conducted on as valid principles, and in as effectual a manner, as it would were we capable of penetrating farther into the arcanæ of Creation.

With this assurance, let us, therefore, resume our discourse.

In doing so, the first idea which occurs to the mind, is, that by the formation of the light, and its division from the darkness, a new agent, a new cause, a new FORCE, was introduced into the system; and this, in reality, was the case. Every cause being accompanied by a corresponding effect, and the definition of "force" being "whatever produces, or opposes the production of motion in matter;"* we must endeavour to discover the legitimate effects, or the motion engendered, by this new *force* thus introduced to such an amazing extent; while we are assured, beforehand, that as it did not *oppose* the production of motion, it must necessarily have *caused* it. Instead, however, of making our enquiries general to the whole of the solar system, we shall restrict them to the phenomena experienced by our own planet; as we may be persuaded, that results similar to those which took place on this, would be common to all the other spheres of the solar economy. Before proceeding farther, it may be well to reiterate the following fundamental positions, namely, that although the earth, during its period of non-rotation, circulated in free space around the sun, under the dominion of the same laws which at present govern its orbital course in the heavens; yet, according to that of gravitation, so long as the earth consisted of the same *quantity* of matter, it *could not deviate, in the smallest degree, in its mean distance from the sun.*† Consequently, as there has been neither any augmentation nor diminution of the mass of matter of which it is composed, ever since it was translated in space, at the beginning, although its materials are now differently combined in the relative position of their molecules, we must conclude, that *it neither did, nor could at any time, for any cause, nor under any circumstances, deviate in the slightest possible degree, from its original orbit;*

* Mechanics, Cab. Cyc. p. 7.

† Connexion of the Sciences, p. 408. Likewise the 70th Theorem.

or, in the language of astronomers—"whatever may have been the form of the ellipse, or successive ellipses, which it has described around the sun, the length of the longer axis of the orbit has continued to be invariable," a truth which it will be found particularly useful to bear in mind, while we go into the following investigations respecting the laws of force and motion.

The first to which we shall have reference is a part of the *fifty-second* Theorem, which states, "*That an irresistible body of analogies leads to the conviction, that the same physical properties, which observation and experience disclose in the smaller masses immediately surrounding us, are possessed by the infinite systems of bodies which fill the immensity of space. That the distribution of heat is regulated by the same laws amongst the bodies of the universe as among those which exist on our globe.*"

At the risk of being considered tiresomely prolix, we must, for the sake of perspicuity—the chief desideratum in close reasoning—call to mind what has already been brought so prominently forward, namely, the creation of the ethereal fluid, or the light, of the first three days; its ubiquity, both as to extension and minuteness; the circumstance of its having been made and completed *before* it was put into motion; its having been subsequently put in motion; and that the motion then given, conferred a state or condition upon it which caused it to become the opponent of attraction. And having these particulars present in the mind, we are next to consider, that as the "distribution of heat" is regulated by the same laws among the bodies of the universe, as among the bodies which surround us, "and the greater masses of the universe, including the earth itself, are playing, though on a greater scale, the self-same part as do the most minute particles of dust which dance in the sun beam, or the still more impalpable atoms of air which float around us;" while the introduction of heat amongst these indivisible molecules of matter, of whose movements we have a more intimate knowledge, from being immediately under our observation, invariably causes them to *expand*, or *separate* from each other. We are warranted, according to what has been announced in the *fifty-second*

Theorem, to conclude, that similar consequences would result, should a proportionate quantity of heat be introduced amongst *the larger indivisible molecules* of the universe. Now, the spheres of the various systems constitute those larger molecules of the universe; and if, in place of contemplating them in general, we restrict our attention to those only of the solar system, and suppose that what we called molecules, should assume the more appropriate name of planets, we assuredly may extend to them the same conditions, especially when we consider that the light was infused almost ubiquously into materialism, and *afterwards* put into motion with a vividity beyond conception, and from these combined reasons finally conclude *that, could they possible have increased their distance from each other, the introduction of the* LIGHT *would, in like manner, have produced a corresponding expansion in the regions of space among the spheres of our system.*

We have just been reminded, however, that owing to certain peculiarities in the law of gravitation, unless a proportional augmentation had simultaneously been made to the respective masses of the planets, they could not deviate in the smallest degree from the orbits in which they commenced to circulate when first translated in space, which is equivalent to saying, that *they could not possibly expand.* While all our previous reasoning and the evidences brought forward have, alike, conspired to prove, that no ponderable element was added to the earth during the protracted period of non-rotation. On the contrary, that this seems to have been sedulously avoided, and the work of deposition and solidification carried on by the combined agency of chemical and electrical influences, and of animal and vegetable vitality. Consequently, unless it can be satisfactorily proved, that on the formation of the light, they did receive some increment to their respective masses, *we must search for other consequences than those of expansion amongst the spheres of the system, as the result of the introduction of this new force;* which being known not to have *opposed* motion, *must,* as the remaining condition of the problem, *have produced it in some direction or other.*

Under this view of the case, and in order to ensure the most thorough conviction, we have only to prove that no aug-

mentation of ponderable matter was made to the earth by the formation of the light. There being minds so reluctant to admit any new doctrine, that rather than believe what has just been stated, they would endeavour to persuade themselves, that the earth and other planets received such an increase to their respective masses by the impartation of light, as would enable these orbs, in virtue of the proportional law of gravitation, to expand in space, or separate from each other and from the sun; and thereby continue to describe orbits round that central luminary, although of greater circuit than formerly. Fortunately, however, for the cause of truth, the imponderable nature of light has occupied the attention of philosophers of all countries, and has been made the theme of learned and protracted discussion; and is now, we believe, universally admitted to be as stated in the *forty-sixth* Theorem, namely, "*That light and heat either do not possess the property of gravitation, or possess it in so small a degree as to be wholly inappreciable by any known means of measuring it;*" while the several authorities which support that opinion, and are subjoined to the Theorem, can be consulted, should any doubts still lurk in the mind as to the soundness of the assertion, and raise a hope of having discovered an outlet for the expenditure of the new force of which we are treating. But, on the contrary, the unprejudiced adoption of what has been said, and a deliberate perusal of the accompanying evidences, will show the fallacy of such an expectation. There is no method of procedure left, but that of setting about in earnest to look for some more probable manner of accounting for the expenditure of the new force—and force of such amazing power—which was thus introduced into the material universe, by the formation of the light, and its division from the darkness.

The following passage is so apposite with respect to the *levity* of light and heat, that we give it with much pleasure:—

"The question, whether the increase of magnitude caused by raising the temperature of a body arises from its having received any addition of a *material* substance to its mass can only be decided by previously fixing on some one quality which will be regarded as inseparable from matter, and, therefore, the presence or absence of

which being ascertained will decide the presence or absence of the additional portion of matter under enquiry. The quality which seems best adapted for such a test is weight; and the question, whether the increased dimension of a heated body proceeds from its having received any excess of ponderable matter becomes one which is to be decided by direct experiment. Experiments to ascertain this fact have been instituted, attended by every circumstance which could contribute to ensure accurate results, but no change of weight has been observed. We are, therefore, entitled to conclude, that whatever be the nature of the principle which gives increased dimensions to a body, when its temperature is raised; whatever it be which fills the increased interstitial spaces from which its constituent particles are expelled, it is not a ponderous substance—it is not one on which the earth exerts any attraction—it is not one which if unsupported would fall, or if supported would produce any pressure on that which sustains it."*

Let us, therefore, commence this straightforward endeavour, by recapitulating the nature of the forces which maintain the earth, and other bodies of our system, in the respective orbits which they describe around each other. For this purpose we shall introduce the first part of the *fourth* Theorem—" *That the orbital revolutions of the* EARTH *and other planets around the sun, almost in the plane of its equator, and of the satellites around their primaries, are caused by the combination of the sun and the planets' mutual attraction, and an original projectile impulse.*" This will enable us to perceive, that the earth is maintained in its orbit by two nicely equipoised forces, whose conjoint result is to cause its orbital revolution: while we must be made aware of the fact, that those two forces produce one uniform and constant motion, merely from their being so justly proportioned to each other as not to admit of increase or of diminution in either;† or, in other words, *they are incapable of resisting any additional pressure which might be brought to bear upon them; for any such would*

* Hydrostatics, in Cab. Cyc. pp. 142, 143.

† The constancy here alluded to is altogether irrespective of the secular mutations in the form of the elliptic orbits occasioned by the disturbing influence of the other bodies of the system.

infallibly be destructive of the resultant motion. It is requested that this fact may be kept present to the mind, as allusion will frequently be made to it during the reasoning which follows.

Having established these preliminary points, let us now see what is stated in the *seventy-fifth* Theorem—"*That forces, in general, are classed according to the duration of their action into* INSTANTANEOUS *and* CONTINUED; *the effect of the former being produced in an infinitely short time. If the body which sustains it be previously quiescent and free, it will move with a uniform velocity in the direction of the impressed force; but if the body be so restrained that the impulse cannot put it into motion, then the fixed points or lines which resist the motion will receive a corresponding shock, called percussion, at the moment of the impulse; and which, like the force that caused it, is instantaneous. A continued force will produce a continued effect, with corresponding results.*"

Now, the formation of the light, and its division from the darkness, was, to the spheres of the solar system, revolving round each other in darkness, equivalent to the application of an expansive force amongst them, whose effects they must either have *resisted*, *expended*, or *receded* from. But these celestial bodies, we have just learnt, were from the beginning, and still continue to be, maintained in their respective orbits, by two divellent forces, in just and delicate equipoise; consequently, they were incapable of either deviating from their assigned orbits, and, by expanding in space, thus to retreat from it; or of continuing to revolve in their orbital paths had they been made to resist the newly applied force: and this too, whether its direction was from the centre of the system towards the circumference; from the circumference towards the sun; or from any point intermediate between these directions; for, in either of these cases, a pressure equal to the applied force would require to have been either *borne* or *retreated* from; while, as has just been demonstrated, they could neither *resist* any additional pressure on their orbital motion, nor *recede* before it. Consequently, we may safely conclude, *that in neither of these ways was the newly formed expansive force either resisted, receded from, or expended.*

We shall now recur to the first part of the *seventy-sixth* Theorem, namely, "*That if a point on which a force be applied is free to move in a certain direction not coinciding with the applied force, it will be resolved into two elements, one of which will be in the direction in which the point is free to move, and the other at right angles to that direction. The point will move in obedience to the former element, and the latter will produce percussion or pressure on the point or line which restrains the body.*"

An attentive perusal of those parts of the "Treatise on Mechanics" which contributed to the formation of this *Theorem* will show, that when a force is applied to any body free to move in a direction not coinciding with that of the applied force, the force itself will be resolved into two elements, *one of which will produce percussion or pressure on the points or lines which restrain the body.*

But having been made aware that neither the earth nor any of the planets, in consequence of the nice adjustment of the powers which maintain them in their respective orbits, *could resist any degree of pressure whatever,* we must also abandon any hope we may have allowed ourselves to entertain, that in this way the application of the force which was introduced into the solar system, by the formation of the Light and its division from the Darkness, can be satisfactorily accounted for.

This brings us to the consideration of what is stated in the *seventy-seventh* Theorem—"*That if a solid body, moveable on a fixed axis and susceptible of no motion, except one of rotation on that axis, be submitted to the action of instantaneous force, one or other of the following effects must ensue:—*

1st. The axis may resist the force and prevent any motion.

2nd. The axis may modify the effect of the force, sustaining itself a corresponding percussion; and the body will receive a motion of rotation; or

3rd. The force applied may be such as would cause the body to revolve round the axis, even were it not fixed; in which case the body will receive a motion of rotation, but the axis will suffer no percussion.

And that the same results proceed from the application of continued forces."

Applying the truths contained in this Theorem to the case in question, it becomes obvious, from what has been already stated, that the *first* of these conditions could not possibly have taken place. *The earth's axis could not have resisted the force and prevented the motion.* For the same reasons neither could the *second* consequence have followed the application of the force in question, for the earth's axis could not "*have modified the effect of the force and have sustained a corresponding percussion.*"

And, therefore, as neither of these two conditions of the Theorem could have taken place, we are constrained to admit the remaining one, and to conclude

That the consequences of the expansive force introduced into the material universe by the formation of the light and its division from the darkness, when applied to the non-rotating spherical earth, was, to cause it to revolve around its axis in such a manner that the axis suffered neither pressure nor percussion.

This could only have been accomplished by the new force having acted in such a manner, that its power was exerted in a tangential direction, thereby causing no pressure on the axis of the body which was impressed with rotatory motion.

The soundness of this final conclusion is corroborated in a remarkable manner, by the speciality with which the portion of Scripture having reference to it is worded; for be it observed, the rotation of the earth is there treated of, not as a *primary* law, but as an *effect;* and an *effect* produced by the operation of a law *directly* mentioned, with others which, from only being implied, must have been known to have previously existed.

Let us refer more immediately to the words of inspiration, that we may make this assertion more evident: "And God saw the light that *it was* good, and God divided the light from the darkness." Now, behold the infinite wisdom of this—to have introduced the light into the universe without having conferred upon it the *principle of expansion;* that is, a nature opposed to that of attraction (if such an idea can, for a moment, be entertained), would have been either to have made it *wholly inert*, to have constituted it an *addition* to the force

which previously existed, or a *deduction* therefrom. But neither of these three cases would have suited the designs of the Creator upon that occasion, or have produced the effect which he intended; it was therefore necessary, that a *principle, acting in a direction different from any of the previous powers,* should be called into existence before the planets and other spheres could, as its spontaneous consequence, have rotated around their axes. This was effectually done by *dividing the light from the darkness after it had been completed in its unrelated and intimate nature*, and recognised as being "good."

And, indeed, we cannot, if we would, conceive any means more thoroughly effectual for accomplishing this end than that which was adopted by the Almighty. Space, by his creative command, was filled almost *ubiquously* with this proto-creation of the Mosaic week—the *ethereal fluid.* Not an interstice, however minute, escaped from the all-pervading command—"Let there be light." Half-formed materialism did not require to ask "where?" The fiat, like its author, had an Omnipresent application, and light, as nearly as matter could be, was to be *everywhere.* And when, in compliance therewith, the very pores of materialism had been thus filled up with the penetrating, elastic, but motionless fluid—so perfect in itself as even in the sight of God to appear to be "good"—it was then made *expansive* with a vividness and power which can scarcely be imagined, and had not the same unerring wisdom conferred a tangential direction upon it, and had not the spheres thereby been made to revolve beneath its constraining influence, it is difficult to say what might have been the result of the distending impetus of this newly-formed power.

It should, likewise, be considered that the light could only have been divided from the darkness by a special act of the Creator; because it is a general law of materialism—made known to us by the science of mechanics—that where any two forces, moving in opposite directions impinge upon, or come into contact with one another, they are either neutralized, if of equal power, or the greater overcomes and destroys the inferior; light and darkness being as nearly as possible everywhere present, and *moving in opposite directions,* nothing but a special decree of Omnipotence could, by excepting them

from this general law, have enabled them, while they so travelled, not to neutralize or to destroy each other's influence.

After making the announcement which we quoted above, the inspired historian goes on to state, "And God called the light Day, and the darkness called he Night. And the evening and the morning were the first day;" an *indirect* method of informing us, without expressly stating it, *that the earth at this time performed its first rotation;* for without diurnal motion, there could have been neither morning nor evening, day nor night. Here it is again to be remembered, that the words of this chapter of Genesis, *were the laws which constituted Nature itself.* All that is present to our perceptions, and we, ourselves, existing merely in virtue of these laws, and others of similar potency, which, although not specifically mentioned, *are as clearly implied;* therefore it is essential to distinguish when a law is directly announced, and when it is only implied by the mention of its effects; for in this latter case, a law causing any effect either wholly or in part not directly recorded in this chapter *must have previously existed,* as it co-operated to produce that which is expressly narrated. The truth of this observation is forcibly exemplified in the case we are now contemplating; while the observation itself is akin to, and perfectly accordant with the fundamental principles laid down by us at the commencement of our work.

It has been aptly observed by a recent writer, "that Sir William Herschel soon came to the conclusion that gravitation, although it accounts for the proximity of bodies, does not alone account for the *stability* of systems; there must also be orbital motion;"* so we, on our part, assert that although rotatory motion is to be attributed to the effects of the expansive principle introduced into the universe on the first day of the Mosaic week; nevertheless, the formation of the light, and even its division from the darkness, although this conferred upon the former properties diametrically opposed to attraction, could not of itself have caused the rotation of the earth around its axis, *unless it had been previously counterpoised in space by two nicely-balanced powers, which left it*

* Nichol's Architecture of the Heavens, p. 75.

free to revolve, while they enabled it to do so as around a fixed axis. At the same time, by a dexterous application of these principles to the verses just quoted, in which no mention is made of such pre-existing laws; while the formation of the light and its division from the darkness, although not sufficient of themselves to have caused the change contemplated, are announced to be *the completion of what was required to cause the revolution of the earth around its axis*, another great truth is clearly brought out, namely, that both *centripetal* and *centrifugal* force must have existed from "the beginning." By this we are enabled to explain how the earth and other planets could have revolved around the sun, and the whole round the common centre of gravity, although the central orb was not, as now, illumined. Otherwise, it is impossible to conceive a system composed of various spheres, some revolving round others, partly by the influence of attraction, unless they had been impressed with centrifugal impetus; or, on the other hand, to imagine one sphere revolving round another, or rather around their common centre of gravity, without the existence of attraction, as an antagonist to the centrifugal force thereby generated. Hence, if it can be proved, that the whole of the stratified masses constituting the greater part of the earth's rocky crust, were formed during the period *when as yet the earth was not impressed with diurnal rotatory motion*, it must follow as a necessary consequence, that the duration of its non-rotatory revolution around the *unillumined* sun was that required for the deposition and formation of those masses.

In order to show that the earth actually performs a double revolution in space, and thereby relieve the mind from any doubt that may arise from the suspicion, that the motion of diurnal rotation is either necessarily or in any manner dependant on orbital motion, we refer to the following truths contained in the *third* Theorem—"*That the* EARTH *has a double movement in space; one by which it revolves around its own axis in 24 hours solar time, or in 23 hours 56′ 4.09″ sidereal time, and another movement whereby it performs its periodical revolution in an invariable plane around the sun in what is termed the tropical year of 365 days 5 hours 48′ 49″-7. That these two motions are entirely independent of each other.*

And that if the Earth did receive its double movement from a single impulse, it is considered by computation that the impulse must have passed through a point about twenty-five miles from its centre."

As a corroboration we shall subjoin what is said in the *Connexion of the Sciences*, regarding the independency of these two movements :—

"If a sphere at rest in space receive an impulse passing through its centre of gravity, all its parts will move with an equal velocity in a straight line ; but if the impulse does not pass through the centre of gravity, its particles having unequal velocities will have a rotatory or revolving motion at the same time that it is translated in space. These motions are independent of one another ; so that a contrary impulse passing through its centre of gravity will impede its progress without interfering with its rotation. As the sun rotates about an axis, it seems probable if an impulse in a contrary direction has not been given to its centre of gravity, that it moves in space accompanied by all those bodies which compose the solar system ; a circumstance which would in no way interfere with their relative motions ; for, in consequence of the principle that force is proportional to velocity, the reciprocal attractions of a system remain the same, whether its centre of gravity be at rest or moving uniformly in space. It is computed that, had the earth received its motion from a single impulse, that impulse must have passed through a point about twenty-five miles from its centre.

"Since the motions of rotation and translation of the planets are independent of each other, though probably communicated by the same impulse, they form separate subjects of investigation."*

"The planets," says the author of the *Architecture of the Heavens*, "move around the sun in orbits almost in the plane of the sun's

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* Mrs. Somerville's Connexion of the Sciences, 3rd edition, pp. 9, 10. Should the views we have adopted of the non-rotation of the earth for ages, and its diurnal motion having been communicated by the formation of the light, and its division from the darkness, be eventually confirmed, astronomers may perhaps be induced to change their conceptions of the *supposed direction* of the impulse which translated it in space. In lieu of being considered, as it now is, to have passed through a point about 25 miles from the earth's centre, it will be found to have passed through the centre of gravity of the spherical non-rotating earth, or tangential to the direction of the sun's attractive influence, which would infer its having arisen from a force *identical in kind with that of expansion.*—AUTHOR.

equator, and in the direction of the sun's rotation on his axis; they rotate on their axes in the same direction, and—with some exception as to Uranus—the whole satellites revolve around their primaries also in that direction, nor are the rotations of these secondary bodies in as far as they are known, subject to a different law. Now, these phenomena receive no explanation from what we usually term the law of gravitation, *inasmuch as gravitation could sustain systems distinguished by no such conditions. Nay, it actually does so*, for the comets are free from all these laws; they move in very eccentric orbits inclined to the plane of the sun's equator at all degrees, and their motions are as often retrograde as direct."*

As we depend chiefly on geological phenomena, which may be termed the *practical* or *tangible* evidences, for establishing the truth of our cosmographical opinions, we shall not bring forward any further theoretical proof in support of the present position, considering what has already been said to be sufficient to convince any unprejudiced mind, as far as mere theory can effect that purpose. But should any one still doubt that the formation of the light and its division from the darkness caused the earth and other spheres to revolve around their axes, we would merely ask them *What then did it do?* It must have done something. The light *must* have had an *effect;* for there is no cause, however trivial, without an effect; indeed it cannot be a *cause* without having an *effect;* and, consequently, we must suppose that this, one of the most stupendous of known causes, the formation of the all-pervading ethereal fluid—termed in Scripture the light, whose uncombined portion alone now illuminates the systems of the universe—must have been attended by an effect of corresponding magnitude. It was not "to give light upon the earth," for this it did not do, we are expressly informed, until the fourth day; therefore we repeat our enquiry, If the first effect of the introduction of the light and its division from the darkness was not that of causing the spheres to revolve, what was it? And again, if the earth and other orbs revolved around their respective axes from the "beginning," how was the *new force*—the introduction of Light into the material universe—*expended* or disposed of?

* Nichol, 1837, pp. 176, 177.

These may appear remarkable questions; but it should be remembered that we are strangely circumstanced, our true position towards the earth's inhabitants being this, that while there is, perhaps, not a single person capable of reflection who for an instant doubts that the earth now revolves around its axis, there is, perhaps, not another being on its surface, at the present moment, who believes, THAT THERE WERE AGES WHEN, ALTHOUGH IT REVOLVED AROUND THE SUN AS IT NOW DOES, IT HAD NO DIURNAL MOTION. It therefore becomes us to strengthen our arguments by all possible means, considering that we stand in the peculiar, nay, the unique position, of not only differing in opinion from all mankind, but are under the necessity, for the same reason, of convincing them that we are right. With this view, before closing the present chapter, we shall make some allusions to a subject which hitherto has been deferred.

In consequence of not considering the Light, *as now received from the sun*, to have been, in any manner instrumental in having caused the sun itself, the earth, and the other spheres of the system to rotate around their respective axes, we have not, hitherto, thought it necessary to bring forward any evidence to show the intense heat which the sun is considered to engender. Nevertheless, as the primary light and the light of the sun are mere modifications of each other, in a manner analogous to the blaze of light which bursts forth, when the charcoal-tipped wires of the voltaic pile are brought into contact by a skilful electrician, after having, by their invisible streams, caused rotation, decomposition, and many other surprising experiments, and the spectators are thereby made to appreciate in a more convincing manner the potency of the unseen element which he had put into activity, and employed in performing those experiments; so we consider, that the light and heat, which now issue from the central orb of our system, may be assumed as an appreciable measure of comparison in any endeavour which we make to form an estimate of the intensity and power of that stream of primary unseen light, which caused the rotation of the spheres of our system, and of every system where rotatory motion is known to exist, which decomposed the water, and formed the atmosphere, which

evaporated the surplus vapour; gathered the water together and left the dry land in possession of stores of their saline associates for the future use of man, animals, and plants; and whose unwearied potency was made to combine in a few hours all the woody textures and fibres of the phanogamous vegetable kingdom; and was afterwards, by the all-powerful hand of God, made to collapse until the stream of invisible light came into contact with that of darkness—whose centre had always been in the sun—or, in other words, until the streams of *expansion* and *attraction* met around the central orb of our system,* and, at the command of the Omnipotent, have ever since sent forth those regulated supplies of warmth and light which sustain all nature; the conjunctive force or intensity of which has drawn the attention of some of the ablest of our modern philosophers, and whose deductions we shall give in a few brief extracts; expressing, previously, our conviction that as the rays of light emitted from the charcoal point are merely the visible manifestion of two streams, whose well-springs are in the voltaic generator behind; so the luminary which enlivens all nature is solely the junction-point of those streams of *attraction* and *expansion* whose fountain is perennial, and whose inexhaustible fulness is from everlasting to everlasting.

The following are the philosophical opinions to which we above alluded, and which, of course, are restricted to what is alone visible:—

"The ocean of light and heat," observes Mrs. Somerville, "perpetually flowing from the sun, must affect the bodies of the system very differently, on account of the varieties in their atmospheres, some of which appear to be very extensive and dense. According to the observations of Schroetz, the atmosphere of Ceres is more than 688 miles high, and that of Pallas has an elevation of 465 miles. These must refract the light, and prevent the radiation of heat like our own. . . . . .

The direct light of the sun has been estimated to be equal to that of 5,563 wax candles of moderate size, supposed to be placed at the distance of one foot from the object. That of the moon is probably only equal to the light of one candle at the distance of twelve

* Sun, the centre of attraction.—Connexion of the Sciences, p. 7.

feet. Consequently, the light of the sun is more than *three hundred thousand times greater* than that of the moon."*

"That the temperature at the visible surface of the sun" says Sir John Herschel, "cannot be otherwise than very elevated—much more so than any artificial heat produced in our furnaces or by chemical or galvanic processes—we have indications of several distinct kinds. First; from the law of decrease of radiant heat and light, which, being inversely as the squares of the distances, it follows that the heat received on a given area exposed at the distance of the earth, and on an equal area at the visible surface of the sun, must be in the proportion of the area of the sky occupied by the sun's apparent disc to the whole hemisphere, or as 1 to about 300,000. A far less intensity of solar radiation collected in the focus of a burning-glass suffices to dissipate gold and platina in vapour. Secondly; from the facility with which the caloric rays of the sun traverse glass, a property which is found to belong to the heat of artificial fires, in the direct proportion of their intensity. Thirdly; from the fact that the most vivid flames disappear, and the most intensely ignited solids appear only as black spots on the disc of the sun, when held between it and the eye. . . . . . The sun's rays are the ultimate source of almost every motion which takes place on the surface of the earth. By its heat are produced all winds, and those disturbances in the electric equilibrium of the atmosphere which give rise to the phenomena of terrestrial magnetism. By their vivifying action vegetables are elaborated from inorganic matter, and become, in their turn, the support of animals and of man, and the sources of those great deposits of dynamical efficiency which are laid up for human use in our coal strata. By them the water of the sea is made to circulate in vapour through the air, and irrigate the land, producing springs and rivers. By them are produced all disturbances of the chemical equilibrium of the elements of nature which, by a series of compositions and decompositions, give rise to new products, and originate a transfer of materials. Even the slow degradation of the solid constituents of the surface, in which its chief geological changes consist, and their diffusion among the waters of the ocean, are entirely due to the abrasion of the wind and rain, and the alternate action of the seasons; and when we consider the immense transfer of matter so produced, the increase of pressure over large spaces in the bed of the ocean, and diminution over cor-

* Connexion of the Sciences, pp. 253, 254.

responding portions of the land, we are not at a loss to perceive how the elastic power of subterranean fires thus repressed on the one hand, and relieved on the other, may break forth in points when the resistance is barely adequate to their retention, and thus bring the phenomena of even volcanic activity under the general law of solar influence.

"The great mystery, however, is to conceive how so enormous a conflagration (if such it be) can be kept up. Every discovery in chemical science here leaves us completely at a loss, or, rather, seems to remove farther the prospect of probable explanation. If conjecture might be hazarded, we should look rather to the known possibility of an indefinite generation of heat by friction, or to its excitement by the electric discharge, than to any actual combustion of ponderable fuel, whether solid or gaseous, for the origin of the solar radiation."*

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* Astronomy, in Cab. Cyc. American edition, pp. 200—202.

SECTION V.

INTRODUCTION OF THE LIGHT; THE CONSEQUENT PROTOROTATION OF THE EARTH; AND ITS DYNAMICAL RESULTS.

CHAPTER XVI.

Geological Phenomena in proof of the Earth's period of Non-rotation, divided into *external* and *internal* evidences, the former consisting of abstract mechanical laws applied to geological manifestations. Centrifugal impetus, engendered by rotation, the admitted cause of the equatorial protuberance of the Earth, and of the oblate form of other planets of our system. Geographical data in corroboration of the former assumption. *Internal* or geological evidences to the same effect. Origin of Continental Ridges and of Oceanic Hollows. Mechanical-dynamic Laws brought forward to account for the elevation of the horizontal concentric strata of the non-rotating sphere. Their change of position, and the vast extension of surface occasioned by the spherical earth having been suddenly transformed into a spheroid of rotation.

Having, in the preceding chapter, presented a vivid idea of the potency of the primary light, by inference, from that of the sun, in order that, if possible, we should leave no essential point undetermined behind us; we shall now proceed to another chain of reasoning entirely distinct from the former, and having for its general object, to explain the manner in which it is considered that the geological phenomena can be be made to prove the non-rotatory period of the earth's existence. And while, as a whole, it is offered as a body of evidence having tangible materials for its basis; yet, for greater perspicuity, it must be divided into two branches: one, whose superstructure is founded on well-known and established, but *abstract principles* of mechanics; and another—the most important—arising from *material* geological phenomena, which

can be seen, weighed, and handled; and which, consequently, carry conviction to the mind—that conviction generally attendant on the evidence of the senses.

We shall commence, as a part of the former division of our proof, with what is contained in the *seventy-second* Theorem. "*That when a body has a motion of rotation, the line round which it revolves is called an axis; in which case every point in the body must move in a circle whose centre lies in the axis, and whose radius is the distance of the point from it. That, sometimes, when the body revolves, the axis, itself, is moveable, and, not unfrequently, in a state of actual motion; the motions of the earth and planets being examples of this kind.*"

Having thus seen that writers on mechanical laws recognise the earth as one of these "bodies" revolving round an axis, in which every point moves in a circle, whose centre lies in the axis, and "whose radius is the distance of the point from the axis," we shall next endeavour to trace, *theoretically*, the consequences which proceed from it. In doing this, let us refer to the first portion of the *seventy-third* Theorem, in which it is clearly stated, "*That the same causes which produce pressure on a body when restrained, will produce motion if the body be free. Accordingly, if a body be moved by any efficient cause, it will, by reason of the* CENTRIFUGAL FORCE, FLY OFF; and *the moving force with which it will thus retreat from the centre round which it revolves will be the measure of the centrifugal force.*"

If, with a knowledge of this upon the mind, we proceed, without losing any time, to the perusal of the *seventy-fourth* Theorem, we shall perceive, at once, what writers on mechanics and astronomy consider to have been the more general results of the revolution of the earth around its axis. Observing, however, that *they* conceive the rotatory motion to have been impressed upon it by the same impulse which caused its orbital revolution, which, although at variance with the fundamental principles of this theory, does not affect the validity of the evidence as far as it goes. In the Theorem alluded to, it is stated, "*That to the centrifugal force arising from the rotation of the earth around its axis, and to its greater opposition to gravity in the equatorial regions, is attri-*

buted the protuberance of its form in those regions; or the excess of the equatorial beyond the polar diameter. And that this opinion is corroborated by the excessive oblate form, and corresponding rotatory velocity of Jupiter."

As this is rather an interesting point, we shall take the precaution to examine some of its evidences in detail, before we go on to consider the actual results with more detention.

"The most remarkable, and important manifestation of centrifugal force"—says the writer on Mechanics, in the Cabinet Cyclopædia—"is observed in the effects produced by the rotation of the earth upon its axis. This rotation causes the matter which composes the mass of the earth to revolve in circles round the different points of the axis as centres, at the various distances at which the component parts of this mass are placed. As they all revolve with the same angular velocity, they will be affected by centrifugal forces, which will be greater or less in proportion as their distances from the centre are greater or less: consequently, the parts of the earth which are situated about the equator will be more strongly affected by centrifugal force than those about the poles. The effect of this difference has been, that the component matter about the equator has actually been driven farther from the centre than that about the poles, so that the figure of the earth has swelled out at the sides, and appears proportionately depressed at the top and bottom, resembling the shape of an orange. The exact proportion of the polar to the equatorial radius has never yet been certainly ascertained. Some observations make the equatorial radius exceed the polar radius by $\frac{1}{277}$, and others by $\frac{1}{335}$. The latter, however, seems the more probable. It may be considered to be included between these limits.

"The same cause operates more powerfully in other planets which revolve more rapidly on their axis. Jupiter and Saturn have forms which are considerably more elliptical. . . . . . But there is another reason why the centrifugal force is more efficient in the opposition which it gives to gravity near the equator than near the poles. This force does not act from the centre of the earth, but is directed from the earth's axis. It is, therefore, not directly opposed to gravity, except on the equator itself. On leaving the equator, and proceeding towards the poles, it is less and less opposed to gravity."*

* Mechanics, in Cab. Cyc. pp. 105, 106.

"The forms of the planets"—it is stated in the "Connexion of the Sciences"—"result from the reciprocal attraction of their component particles. A detached fluid mass, if at rest, would assume the form of a sphere, from the reciprocal attraction of its particles. But if the mass revolve around an axis, it becomes flattened about the poles and bulges at the equator, in consequence of the centrifugal force arising from the velocity of rotation, for the centrifugal force diminishes the gravity of the particles at the equator, and equilibrium can only exist where these two forces are balanced by an increase of gravity. Therefore, as the attractive force is the same on all particles at equal distances from the centre of a sphere, the equatorial particles would recede from the centre, till their increase in number balance the centrifugal force by their attraction. Consequently, the sphere would become an oblate, or flattened spheroid; and a fluid partially or entirely covering a solid, as the ocean and atmosphere cover the earth, must assume that form in order to remain in equilibrio. The surface of the sea is therefore spheroidal, and the surface of the earth only deviates from that figure where it rises above, or sinks below the sea. But the deviation is so small, that it is unimportant when compared with the magnitude of the earth; for the mighty chain of the Andes, and the yet more lofty Himalaya, bear about the same proportion to the earth that a grain of sand does to a globe three feet in diameter. Such is the form of the earth and planets. The compression or flattening at their poles, is, however, so small, that even Jupiter, whose rotation is the most rapid, and, therefore, the most elliptical of the planets, may, for ordinary purposes, from his great distance, be regarded as spherical."*

These quotations are very satisfactory and conclusive so far as they go, but as we have occasion for considerable exactitude in the present enquiry, we must proceed in quest of such investigations as shall determine the precise amount of the centrifugal force, in order to be convinced, that the rotundity of the earth's equatorial diameter accords with deductions made by *a priori* calculations. With this design we shall resort to the *first* Theorem, in which it is stated—"*That the* EARTH *is a spheroid of rotation, whose equatorial exceeds its polar diameter about twenty-six miles, the former being* 7,925, *the latter* 7,899

* Connexion of the Sciences, 3rd edition, pp. 8, 9.

miles. That the oblateness of this ellipsoid, deduced from actual measurement, although somewhat less than mathematicians affirm it should be, from calculations based on its dimensions, time of rotation, component materials, law of gravity, and centrifugal force, nevertheless corresponds as nearly as the data for calculation will admit." And any, or all, of the numerous authors on whose accredited writings that elementary theorem is founded, may be consulted, should more particular information be required, or any doubt remain on the mind.

Meanwhile, explaining that the dimensions above given are taken from Sir Henry de la Beche's "Manual of Geology," we shall consider it sufficient to adduce one quotation from Sir John Herschel's "Treatise on Astronomy," in which he refers to an "Essay on the Figure of the Earth," by Professor Airy. It is as follows:—

"Without troubling the reader with the investigation, which may be found in any part of the conic sections, it will be sufficient to state, that the lengths which agree, on the whole, best with the entire series of meridianal arcs which have been satisfactorily measured on the earth's surface, are as follow:—

	FEET.	MILES.
Greater equatorial diameter .	41,847,426	7,925.648
Lesser, or polar diameter . .	41,707,620	7,899.170
Difference of diameters, or polar compression	139,806	26.478

The proportion of the diameters is very nearly that of 298,299, and their difference $\frac{1}{299}$ of the greater, or a very little greater than $\frac{1}{300}$."*

After perusing these evidences, it is presumed that no doubt can be entertained as to the CAUSE of the protuberance in the equatorial regions of the earth. This, we believe, is admitted by all who reflect upon the subject, but perhaps few or none consider its oblateness to have taken place *after* it had circulated, as a sphere, for ages round an unillumined sun; and subsequent to the stratified rocks having been deposited from its primitive ocean, in successive concentric hollow spheres, above the unstratified masses, then also in a similarly horizontal

* Treatise on Astronomy, p. 114.

position. Or, in other words, the actual rotation of the earth and the equatorial protuberance occasioned by it, are readily admitted by all; *but the epoch of the commencement of the one, and the origin of the other, have hitherto been considered to coincide with that in which it was translated in space.**

It is our intention to employ the established geological phenomena to prove, that the commencement of its diurnal motion, the "first day" of Scripture, took place when it had geologically attained the state described in the last and preceding sections of this work. While it shall, likewise, be our care to show, that this conclusion is in strict accordance with what is implied in the inspired narrative given in the first chapter of Genesis.

Whatever has hitherto been done by us, to ascertain the precise figure of the earth, and to adduce consequences from it, may be considered as a part merely of the *external* evidences; having been *derived from abstract truths*, founded on abstruse calculations, and profound mathematical manipulations; but those which we are now about to bring forward—which are based exclusively on geological phenomena—may, with perfect propriety, be termed its *internal* evidences, undeniable proofs written in legible characters, within the reach of all who choose to dedicate a few hours of exhilarating exercise to their perusal; and by examination, to assure themselves of the truth of their existence by the strongest of all convictions—ocular demonstration.

At this, as the most opportune juncture, we would observe, that while it was indispensable for the disciples of Copernicus to have recourse to objects *beyond* the earth, to prove that it has

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* It is not our intention to delay the general argument, by fully opening up the interesting field for expatiation which presents itself, when we endeavour to grasp the consequences resulting from the establishment of the fact, that *the diurnal rotation of the Earth took place at a distinct and distant period from that of its orbital motion in space.*

The mind, freed from the trammel under which it has so long laboured in this respect, is at liberty to attribute boldly the *orbital* movements to a force *similar in kind,* because proceeding from the same source, though infinitely vaster and more comprehensive, which, by its tangential influence, caused the whole orbs of the universe to revolve around their respective centres of gravity, the axis of their orbital path. To this we can only allude at present; perhaps we may enter upon it more fully hereafter.—AUTHOR.

orbital and *diurnal* motion; and by means of these distant and distinct objects to overcome the inveterate prejudices of *apparent ocular* conviction to the contrary, confirmed by the imperceptible uniformity of motion in all the parts of the moving mass on which those who doubted were, at the very moment, unconsciously whirled through space—with us it is almost the reverse.

The *actual* rotation of the earth is now so well-established, and is an element so intimately bound up with the conceptions of every living being, that *to assert it ever was otherwise* will be found as incredible as was the announcement of *orbital* motion by Copernicus; while we are in consequence constrained to *adopt an entirely distinct line of proof. External* bodies, except in one or two respects, will be of little avail to us. The earth's rotation finds little sympathy at such remote distances, or, to express ourselves more correctly, the respective rotations of the spheres exercise but little mutual influence on each other; we need not go to them in quest of proof; ours must be almost exclusively drawn from the symptoms of *change within the compass of the earth itself*, and more especially upon its surface—its geological manifestations, and the formation of its continental ridges and oceanic depressions.

But to return to the subject more immediately under notice: let the attention be directed for a moment to the following considerations:—In consequence of the diurnal rotation of the earth being considered to have been impressed upon it by the same impulse which caused its translation in space, it has, hitherto, been looked upon, as a natural result, that the earthy parts should have assumed their present form of equilibrium, while yet capable of doing so, by being in a fluid state either from aqueous, or from igneous liquifaction. Even those who, being most bold, have departed farthest from these conceptions of fluidity, and of coeval movements in space, have only ventured to conjecture, that although it was formed at first, as a sphere, it might gradually have acquired its present relative dimensions, and have become a spheroid of rotation, from the united agency of comminution, disintegration, and the equilibrizing effects of its aqueous portion; but without having explained how the water, which must previously have assumed

the form of rotation, or of rest, came afterwards to exercise those equilibrizing effects on materials of greater density than itself.

Setting this important omission entirely aside for the present, we shall go on to observe in general, that none seem yet to have dealt in earnest with the difficulty ; or have endeavoured to account, in an intelligible manner, for the position of the strata with relation to each other ; or with respect to the primary masses ; or for the formation of the great continental ridges and oceanic hollows ; nor indeed for innumerable other natural appearances. These, when touched upon at all, are treated at respectful distances, or hurried over in general terms, as points not requiring, or which, perhaps, can ill bear discussion, although their importance demands that they should not by any means be overlooked in a theory of the world. In short, they have hitherto been difficult points in all geological disquisitions, which even the most profound thinkers have been glad to dispose of in a transient manner ; and, consequently, when introduced have left no impression of correctness on the minds of the readers ; or, rather, have left them entirely in doubt.

We trust, therefore, it may be considered as an additional pledge for the truth of the present Theory, when it is known, that however careful we may be to avoid misleading any one, *we intend to dwell particularly on those very points, and to bring them forth as our firmest and surest conclusions ;* trusting to prove, that to this very change in the form of the earth, from a sphere to a spheroid, *effected in the short space of twenty-four natural hours,* as recorded in Scripture, are to be traced all those geological and geographical phenomena which have hitherto baffled explanation. We beg, however, it may not be overlooked, that while thus appealing triumphantly to Scripture for the true and only explanation of the cause of that motion, and the effects proceeding from it, we could have made no progress in our attempt, without the surprising and well attested facts brought to light, and established by the intelligence and industry of geologists, naturalists, and other scientific men ; and, therefore, standing as a days-man between those who place implicit faith in the Word of God, while they

turn aside from the lights of philosophy; and those—in a more dangerous position—who, while they gaze with delight on the dazzling lustre of philosophic lore, wilfully shut their eyes to the softer and more glorious light of Scripture; we would be understood as saying to the one: "while you gladly and joyfully listen to the inspired Word of God, be not insensible to the majesty of his works, which are wrought in truth, and are fearfully and wonderfully made." To the other we would say: "amidst the excitement and the exhilarating influences, caused by the investigations of the works of the Great Creator, oh! turn not, we beseech you, a deaf ear to his word. Remember that nature cannot answer *all* your enlightened and intelligent questions; but in order that you should be fully informed of the origin of her stores, you must turn, at last to Nature's God; and to what he has been pleased to reveal in his sacred volume regarding them."

Let not, therefore, believers in the Bible any longer dread the announcements of nature's wonders, for they were all framed and fashioned by their Lord's own hand; nor let the votaries of nature's phenomena any longer deride the worshippers of his word; for without *it* they can neither satisfactorily account for that of which they are in quest, nor return without it to the right path from whence they have so long diverged; but rather, let harmony reign between them, and emulation to advance his glorious cause; for only by their cordial reconciliation and perfect union, can the truth be effectually established.

But to proceed with our argument. Let that be conceived to have been, which in reality was the case, namely: *That the spherical non-rotating earth, geologically constituted as it is described in the preceding section, and performing its periodical revolution around the unillumined sun, by the conjoint influence of two divellant forces, so nicely equipoised as to be incapable of resisting the slightest addition to either, was, by the application of an instantaneous tangential force, made to revolve around its axis, with an angular velocity of* 15° *per hour, and then let us endeavour to determine the results.*

To enable us to do this we shall, first, inform ourselves of what is contained in part of the *seventy-eighth* Theorem:

"*That when a solid body revolves on its axis all its parts are whirled round together, and each performs a complete revolution in the same time; consequently, the angular velocity is the same for all. The tendency of each particle to fly from the axis, arising from the centrifugal force, is resisted by the cohesion of the parts of the mass, and, in general, the tendency is expended in exciting a pressure or strain upon the axis, whose amount depends upon the figure and density of the body and the velocity of its motion.*"

Now, according to the tenor of this Theorem, it is evident, that, when the earth was caused to revolve, the consequences mentioned in it would take place, either by the cohesion of the parts resisting the inclination to fly off, occasioned by the centrifugal force being brought to bear upon them, and the general tendency be expended by exciting a pressure or strain upon the axis; or, the cohesion amongst the particles would be too weak to resist the force engendered by the centrifugal impetus, and they would, therefore, hasten to assume such an arrangement among themselves, as should confer on the whole mass the form of equilibrium under rotation, and so relieve the axis from the strain or pressure indicated above. In effecting which change of arrangement, they would be subjected to all those results proceeding from movement among the various parts of which the whole mass is constituted. By our previous investigations we have been made aware, not only that the earth's axis, could *not* have resisted the consequent strain or pressure to which it would—according to the former alternative—have been subjected, but likewise, that both by calculation and actual measurement it has been ascertained, *that the centrifugal force overcame the cohesion among the parts of the earth's outer crust, and both caused and enabled it to assume the oblate form best adapted to meet the rotatory motion with which it was impressed, and so to relieve the axis from all strain upon it.*

As we trust to prove satisfactorily in the immediate sequel, that this change was effected *after* all the stratified masses preceding the upper portion of the coal measures had been deposited, it follows as a natural consequence of these combined truths, *that in accommodating themselves to the alteration in the*

earth's form, which has just been indicated, from a sphere to a spheroid of rotation, the strata, and other mineral masses, must have undergone very considerable changes in their relative positions.

To be thoroughly convinced of this, in a general way, as also of the fact, that there must have been an instantaneous intrusion of *unstratified* rock amongst the *strata;* let the following consideration be duly appreciated, namely, a spheroid, the mean of whose diameters is 7,912 miles, has upwards of *eight hundred and sixty-one thousand square miles* of more superfice than a sphere whose diameter is 7,899 miles;* and those being the dimensions corresponding to the earth as it now is, and as it was before rotation, it follows—that in order to complete the outer crust of a world, on which such an immense increase of surface had been instantaneously produced, there required to have been provided as instantaneous an amount of solid rock to fill up the expansion which had thus taken place. Nor need it be supposed, that this difference of surface is the estimate at its full extent; for, were the inequalities occasioned by the continents and ocean beds, the mountains and valleys, and other flexuosities of surface, taken into account—the above being merely deduced from plane surfaces—the actual increase would be found to be infinitely beyond that which has been stated.

It must, at once, be confessed, that the superficial extent of rock, instantaneously required to fill up this void, could not have been supplied from any resources residing in *the stratified masses themselves.* For there is no possible way, according to natural cause and effect, whereby a movement of the earth could have occasioned a spreading out of the strata over this enormous increase of surface; and, likewise, over that which has not been taken into account.

We say "according to natural cause and effect," because, for wise purposes, the rotation of the earth around its axis, was ordained to be the *natural* effect of causes instituted directly by the Deity, with power to produce, in sequence,

* It is to be remembered, that we do not admit that the solids of the earth became flattened in polar diameter *after* rotation.

that stupenduous result as their first and chief effect; therefore, we consider ourselves perfectly justified in adopting this language, without in the least attempting to limit the infinite powers of the Creator; but, on the contrary, reverencing those attributes of Omnipotence, we consider ourselves fully authorised, in the present instance, according to the natural connexion between cause and effect, to conclude, that not only was there no possible way whereby the strata could have been made to cover this extra surface, but the vertical positions, which most of them have assumed, would increase our embarrassment, were we to attempt to bring them forward as sufficient for the exigency contemplated; it being well known, and readily admitted, that a plane of any given dimensions, covers a greater concentric surface when horizontal, than when tilted up into any angle whatever out of perfect horizontality; we must, therefore, look to some other phenomena for a satisfactory explanation of this difficulty; although this will lead us into rather a lengthened chain of reasoning, requiring the aid of various Theorems and their accompanying evidences; and the combination of truths, which, perhaps, have never before been brought into juxtaposition; nevertheless, we must continue our labours with patient perseverance, in hopes that they may ultimately lead to satisfactory results.

SECTION V.

INTRODUCTION OF THE LIGHT; THE CONSEQUENT PROTOROTATION OF THE EARTH; AND ITS DYNAMICAL RESULTS.

CHAPTER XVII.

Geological evidences required for the application of the dynamical influences of protorotation. Relative thinness of the earth's crust when compared with its semi-diameter. The existence of this "outer shell" of the earth established. Relative densities of the materials composing the amorphous, and the stratified formations of which it consists. Concluding deduction from these investigations—that the relative distances from the centre of gyration being considered equal, the greater density of the older amorphous masses would occasion their being impelled further from the centre; and consequently cause them to perforate, or to raise up the superincumbent or lighter strata, when the whole concentric mineral envelope of the non-rotating sphere burst asunder and became transformed into continental ridges, oceanic hollows, hill and dale, by the centrifugal impetus of the Earth's protorotation, occasioned by the introduction of the Light and its division from the Darkness.

With reference to what was stated at the conclusion of the last chapter, the first point to which we shall, in this, direct the attention, while endeavouring to establish it, is the relative insignificancy of the estimated thickness of the *earth's outer crust,* in comparison with its *entire radius.* With this view let us, in the first instance, have recourse to the *twenty-first* Theorem, to be assured that there is such a thing understood among geologists as an "outer crust of the earth." *All geologists make use of terms indicating, that their discourses have reference to an "external crust," "outer coating," or, as it is sometimes called, "shell" of the earth, but generally without explaining to what depth these are considered to penetrate into the viscera terræ; yet sufficient has been said to show that*

these expressions are considered to refer to that which has limits not far from the surface; and even, in a few instances, an attempt has been made to draw a clear line of separation, at no great depth below the surface, between the solid crust and the supposed internal masses.

In selecting evidences from among the numerous authorities for that opinion, we shall give what may be considered the expression of a pretty general one on this point, since Dr. McCulloch takes it up with the intention of *refuting it*, when treating on "*the depth of the strata beneath the surface.*"

"It has," he says, "been ignorantly made a matter of reproach to geologists, that they reason respecting the structure of an earth to which they had no further access than by operations that ought to be considered but as scratches on its surface. It has been said that the highest mountains are but as dust, and the deepest mines but as invisible punctures on a common geographical globe."*

Although he endeavours to set aside the main bearing of this upon the geological points then under his discussion, he concludes by giving it as *his* opinion,

"That we have no reasons *a priori* for supposing that strata deposited from an ocean, however ancient, can exist beyond a certain, however undefined depth."†

"When we examine," observes Mr. Lyell, "into the structure of the earth's crust (by which we mean the small portion of the exterior of our planet accessible to human observation), whether we pursue our investigations by aid of mining operations, or by observing the sections laid open in the sea cliffs, or in the deep ravines of mountainous countries, we discover everywhere a series of mineral masses which are not thrown together in a confused heap, but arranged with considerable order; and even where their original position has undergone great subsequent disturbance, there still remain proofs of the order that once reigned."‡

"Beneath the whole series of stratified rocks," says Professor Buckland," that appear on the surface of the globe, there probably exists a foundation of unstratified crystalline rocks, an irregular sur-

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* Geology, vol i. p. 94. † Ibid, p. 96.

‡ Principles of Geology, vol. iii. p. 8.

face, from the detritus of which the materials of stratified rocks have in a great measure been derived—amounting, as we have stated, to a thickness of ten miles. This is indeed but a small depth in comparison with the diameter of the globe; but, small as it is, it affords certain evidence of a long series of changes and revolutions; affecting not only the mineral condition of the nascent surface of the earth, but attended also by important alterations in animal and vegetable life."*

But let us turn from these generalities to actual perforations of the strata, which will serve our present purpose fully as well. The first collective thickness of these which we find recorded anywhere is by Sir Henry de la Beche, when treating of the carboniferous group; for, says he—

"From the careful examination of the Forest of Dean by M. Muschet, we have a detailed list of the various beds of the coal measures, carboniferous limestone, and old red sandstone, the whole constituting a collective thickness of about 8,700 feet; the coal measures being 3,060 feet in depth, and the limestone 705. The mass reposes on the grauwacke (transition) limestone of Long Hope and Huntly."†

We find the following estimates of the collective thickness of the various formations, from the coal measures downwards to the grauwacke system, given by Professor Phillips, viz:—

	YARDS.
"Coal.—Upper, middle, and lower	1,000
Millstone Grit.—Upper, middle, and lower	300
Carboniferous Limestone.—Three distinct formations	600
Old Red Sandstone.—{Minium 100, Maximum 3,300} mean	1,700
Ludlow Rocks.—Sandstone, limestone, and shale	660
Wenlock Rocks.—Lime and shale	600
Caradoc Rocks.—Shelly limestone and sandstone	830
Llandeilo Rocks.—Calcareous luminated beds	400
Grauwacke System.—Unknown."‡	

These numbers unitedly make up six thousand and ninety yards, or 18,370 feet, supposing each formation to be invari-

* Bridgewater Treatise, vol. i. p. 42.

† Manual of Geology, p. 439.

‡ Treatise on Geology, pp. 36, 37.

ably superimposed the one on the other; but which, we believe, is seldom the case.

In a recent popular work, which indeed has been issued while we were preparing for the press, we find the following evidence respecting not only the assumption of the earth having an outer crust, but also its presumed thickness. It is given in reference to Part II. of Mr. Henessy's *Researches in Physical Geology*, communicated to the Royal Society by Major Beamish: the part we have to do with, at present, being Clause 2nd, which states that—

"By employing the values of the constants obtained in Section IX., it appears, that the thickness of the earth's crust cannot be less than 18 miles, and cannot exceed 600 miles."*

While it is to be regretted that the present state of science, in its attempts to penetrate into the *viscera terræ*, should be accompanied by results so vague and indefinite as to be almost of no value, nevertheless, such is the strength of our position, that, in pursuing our argument to a successful termination, we can afford to assume the *mean* of all these divergent estimates, even including the extreme one revealed by Mr. Hennessy's mathematical researches, as the thickness beyond which it cannot be. As a corroborative process we think we can reach a deduction, equally conclusive for our present purpose, by comparing the height above the sea level of the most elevated mountain ranges on the face of the globe with its radius, or semi-diameter. On this subject we have the following very pointed and convincing testimony, already quoted, but with which we shall close this part of our evidence:—

"The surface of the sea," observes the accomplished author of the Connexion of the Sciences, "is therefore spheroidal, and the surface of the earth only deviates from that figure when it rises above or sinks below the level of the sea. But the deviation is so small that it is unimportant when compared with the magnitude of the earth; for the mighty chain of the Andes, and the yet more lofty Himalaya, bear about the same proportion to the earth, that a grain of sand does to a globe three feet in diameter."†

* Year Book of Facts, 1850.

† Connexion of the Sciences, p. 8.

From which it results, that if the estimated elevation of nearly 27,000 feet be thought unworthy of being taken into account, when estimating the diameter of the earth, neither is the mean thickness of the earth's crust comparatively worthy of notice. Thus we have come to one certain conclusion, which we trust will be made available in determining the question we are at present discussing. It is this: that during the non-rotatory period of the earth's existence, the perpendicular distance, from the superior surface of the coal measures to the inferior strata which repose on the unstratified rocks, is so insignificant, in comparison with the radius of the earth, that for any purpose wherein those two limits require to be adduced, they may be assumed—for all practical purposes—as equi-distant from the centre of gyration.

We must next endeavour to determine, if we possibly can, the relative densities of the several classes of rock, especially of the primary and older stratified masses; and of the more modern of the secondary formations, in order to institute a comparison between them. This point, however, appears somewhat difficult to determine with any degree of precision, for it seems hitherto to have attracted but little attention as a specific question; although there is abundance of evidence to prove, in a general way, the commonly received opinion, that our globe is formed of materials whose density increases from the surface to the centre. In support of the point, generally, which we wish to establish, namely, the greater specific gravity of the older rocks, we offer, first of all, the following clause from the *twenty-third* Theorem:—"*That they (geologists) also concur in considering the primary rocks, besides being deficient in organic remains, to be more compact and crystalline in texture than the others.*" The following are some of the authorities for that opinion:—

"When we trace," says Dr. Fleming, "the characters of the different depositions which have taken place, from the newest alluvial beds to the oldest transition rocks, we witness very remarkable gradations of character. The newest formed strata are loose in their texture, and usually horizontal in their position. In proportion as we retire from these towards the older formations, the texture becomes more compact and crystalline, and the strata become more

inclined. These characters may be traced by comparing the common loose marl of a peat-bog with the former chalk ; the compact floetz limestone with the transition marble ; or the peat itself with the older beds of wood coal, or the still older beds of coal of the independent coal formations. The organic remains in the newer strata are yet unaltered in their texture, and easily separable from the matter in which they are embedded. In the older rocks the remains are changed into stone, and intimately incorporated with the surrounding rocks. These facts make us acquainted with the original condition of the matter with which the organic remains were enveloped, and lead us to believe that the bed now in the form of limestone or marble was once loose as chalk, or even marl ; that coal once resembled peat ; and that the strata of sandstone and quartz rock were once layers of sand."*

Sir Henry de la Beche, when treating of the *Non-fossiliferous Stratified Rocks*, says—

"From various circumstances, many of the lowest fossiliferous rocks assume the mineralogical character of those in this class as to be indistinguishable from them, except by geological situation ; but it may be assumed that, as a mass, the strata in this division are far more crystalline than in those of the superior stratified rocks, the origin of which seems chiefly mechanical."

And of the *Unstratified Rocks*, he states—

"Their great characteristic is a tendency to a crystalline structure, though in many this cannot be traced. Every gradation from the crystalline to the non-crystalline structure can frequently be observed in the same mass. The minerals, felspar, quartz, hornblende, mica, dialloge, and serpentine enter largely into the composition of these rocks, more particularly the former."†

Mr. Lyell in one short passage, when treating of the *Metamorphic Rocks*, says—

"Nor should it be forgotten that, as a general rule, the less crystalline rocks do really occur in the upper, and the more crystalline in the lower part of each metamorphic series."‡

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* Letter in Edin. Jour. No. 15, January, 1823, pp. 120, 121.

† Manual of Geology, p. 37. ‡ Elements, vol. ii. p. 416.

Professor Phillips, in his Treatise, says—

"Induration, or consolidation to a high degree, is a general property of the primary strata, composed of siliceous, argillaceous, and calcareous rocks. There is, in fact, no sand, no clay, no marl in the whole series."*

Besides these general evidences, we are, fortunately, supplied with proof of a more specific character by the accurate experiments made by Lord Webb Seymour and Professor Playfair, on the mountain of Schehallien, and whose results have been given to the world by the latter accomplished writer. The whole is so interwoven together, and dependant on mathematical calculations, that a satisfactory abstract can hardly be formed of it, but the following short extract seems to convey all the evidence we require for the present:—

"One thing only seemed wanting," says Professor Playfair, when alluding to Dr. Maskelyne's astronomical observations made on that mountain in 1774, "to give to the determination of the earth's density all the accuracy that could be obtained from a single experiment, namely, a more accurate knowledge of the specific gravity of the rock which composes the mountain, as being the object with which the mean density of the earth was immediately compared. The specific gravity of that rock was assumed to be to that of water as 5 to 2, which, though it be nearly a medium when stones of every kind from the lightest to the heaviest are included, is certainly too small for Schehallien, the rocks of which belong to a class of a specific gravity considerably above the mean."†

After giving the particulars of the various specimens employed, and tables of their individual densities, he goes on to state—

"From the inspection of the preceding table it is evident, that the specimens relatively to their specific gravity may be divided into two classes sufficiently distinct from one another. The specimens of granular quartz are in spec. gr. comprehended between 2.61 and 2.66, nearly; and the mean is 2.639876. The micaceous rocks, including the calcareous, are contained between the limit 2.7, and

* Page 71.

† Playfair's Works, vol. iii. p. 404.

3.06; the mean of all the 15 specimens being 2.82039. Now it happens fortunately that these two classes of rocks distinguished by their spec. gr. are also distinguished by their position, so that the line which separates them can be accurately traced out on the face of the mountain."*

From what has now been said we have acquired another important *datum* to enable us to continue our present enquiry; for we have been made aware by these evidences, that the stony masses which constitute the unstratified rocks, their associated schists, and the older stratified formations, generally speaking, exceed in specific gravity the latter ones, which are not so perfectly consolidated from age or pressure. Or, in other words, *that the specific gravity of the earth's rocky crust, of the ancient globe, increased in proportion to the distance from the submarine surface of that period.*

With these data which we have thus acquired, namely, the greater specific gravity of the older or *then* inferior rocks; and the equality of distance at which the upper and under surfaces of the stratified envelope of the globe, for all parallels of latitude, may be considered to have been in relation to the centre of gyration, let us recur to the laws of mechanics, and endeavour to discover what would be the effect of the rotation of the earth on materials so circumstanced. We find it stated in a part of the *seventy-third* Theorem, "*That weights which are as one to two at equal distances, with the same velocity, will have their centrifugal force increased as the mass of the moving body increases.*"

This rule embraces all the circumstances of the case which

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* Ibid p. 421. The result of these delicate lithological experiments, although in their general tenor affording the favourable testimony expressed in the extract above given, yet reveal an anomaly which candour induces us not to conceal; we allude to the circumstance of the micaceous and calcareous specimens being of greater specific gravity than the granitic, which form the apex of the mountain, and which, according to our views, ought to have been the heaviest. At first this appears an irreconcileable difficulty, but on applying the 53d Theorem to it, it serves to confirm another very interesting truth, namely, that although the granitic mass, previous to being fused by friction, was of greater specific gravity than those which overlaid it, on crystallizing it expanded, while the aluminous contents of the others, on heating, became contracted, and thereby a change of relative densities took place.—AUTHOR.

we are now investigating; for, by the rotation of the earth around its axis, the angular velocity, and consequently the centrifugal impetus, was the same for all places on the same parallels of latitude; the perpendicular distances, between the upper and under surfaces of all formations overlying each other, might for each mass be considered equally distant from the centre of gyration; while their relative densities, although not as one to two, were sufficiently diverse to cause a difference in their centrifugal impetus, and, according to the above law, would be made to fly further from the axis of the earth, which, in this case, was also that of gyration.

This, then, is another step towards the termination of our present enquiry; for we have been made aware, that when the globe was made to revolve, there would be unequal centrifugal forces engendered among the several masses constituting the envelope of the spherical earth; and in order to come to a final conclusion, we have only now to combine it with what was established when we formerly applied the *seventy-eighth* Theorem, namely, "*That the centrifugal force overcame the cohesion among the parts of the earth's outer crust, and caused them to burst asunder, in order to assume the oblate form corresponding to the rotatory motion with which it was impressed.*" For their combination must persuade us, "*That in the general movement which took place among the stony masses constituting the earth's outer crust, when thus broken up, and unequally impelled from the centre, the undermost or heaviest would be caused to perforate or heave up, if they did not entirely pierce through, the stratified masses which reposed upon them.*"

To this conclusion it is considered we must, of necessity, come, as the legitimate deduction of what has been stated in our preceding argument.

No doubt, the diverse increments in the centrifugal impetus as zones were nearer to the equator, and the oblique action, in the polar regions, of gravitation upon this newly-engendered force, will together eventually aid in removing the difficulties which, at present, interpose to prevent our accounting satisfactorily as well for the peculiar sweep which the three great continental ridges have assumed, as for the particular lines of

direction which mountain chains have taken when they alike rose up at his command, and "stood fast."* The chief difficulty in this branch of enquiry consists in our ignorance, as to the way in which the crust of a world should break up when caused to fly asunder by the sudden impetus of protorotation. This, however, would in some degree be obviated, were we to admit, in strict analogy with what other works of the same Omniscient Creator teach us, that deposition, by means of the great luni-solar current, and of animal and vegetable agency, may have been so arranged and carried on, that there were sutural lines prepared parallel to the axis, whose divergence from perfect parallelism, when they became apparent by dehiscence, was occasioned by the action upon them of the forces engendered by protorotation.†

It is not our intention, however, to push this particular point any farther; we merely alluded to it as one with regard to which the Dynamical Theory will be found to lend much assistance; especially to those who are dedicating profound mathematical reasoning to the solution of the great problem of the inequalities of the earth's outer crust. Fortunately, our general argument can be prosecuted altogether irrespectively of this investigation, and we shall, accordingly, proceed with our reasoning.

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* Psalm xxxiii. 9.

† Eleventh Theorem.

SECTION V.

INTRODUCTION OF THE LIGHT; THE CONSEQUENT PROTOROTATION OF THE EARTH; AND ITS DYNAMICAL RESULTS.

CHAPTER XVIII.

Introductory advertencies. Modification, according to latitudinal zones, of the dynamical influence of the Earth's first diurnal motion. Several distinct effects which proceeded coevally from the centrifugal impetus engendered by protorotation. Evidences of this having taken place *after* the stratiform masses had been deposited and become indurated, deducible from the diversified surfaces assumed by the *terraine* and by the *aqueous* portions of the Earth, as co-results of the same cause. Evidences to the same effect derived from the great continental ridges and oceanic depressions of the globe. And finally, the strong testimony which these geological and geographical manifestations, together with the filling up of the equatorial inequalities with deep and widely-spread masses of travelled, mineral debris and earthy matter, bear to the correctness of the Dynamical Theory.

Before proceeding to trace more circumstantially, the important results emanating from the general convulsion of the earth's rocky frame, in accommodating its masses to the modified form which its protorotation caused it to assume, we consider it proper to make the following opportune advertencies.

The effects, proceeding from the dynamical law which we have been contemplating, are to be considered applicable more especially to points of equal latitudes; and to hold good with regard to all masses immediately superimposed on each other; whilst a different and more complex rule requires to be applied, when it is wished to ascertain the comparative results for points of divergent latitudes. In consequence, for example, of parts within 25° of the equator being at much greater relative distances, from the common axis of gyration, than those of

higher latitudes, and, consequently, falling within the dominion of the second rule of the *seventy-third* Theorem, a somewhat different effect would take place with regard to them. For, although the circumstances, mentioned in the previous argument, would undoubtedly cause all more weighty rocks to rise up from beneath the incumbent ones of less dense material, *at every point along the whole line of axis, except when very near the poles;* it follows, from the observation just made with respect to unequal distances from the centre of gyration, *that the violence of protrusion would not only be in proportion to proximity to the equator, but under a parity of circumstances, the whole moveable mass, upper, and under, and all between, would, within the tropical zone, be forced farther from the axis, and thereby caused to form more elevated continents and deeper oceanic hollows.*

The revolution of the earth around its axis having been the cause of innumerable important phenomena, radiating from it as a common centre, they were consequently all undergoing their phases, assuming their forms and states, and speeding to their respective destinations at one and the same period of time; and, therefore, in order to assimilate the description to the events which took place, they should, were it possible, be all described simultaneously. But as many details require to be gone into, several difficulties to be overcome, evidences to be brought forward, positions laid down, and conclusions drawn from the whole, this rapidity of description, however desirable, cannot be accomplished, for some order of sequence must be observed; hence the necessity for this advertence, that the mind may be prepared for the unavoidable discrepancy which must, of necessity, take place between the simultaneous rapidity of the events themselves, and the unavoidable dilated explanation which we are about to attempt of them. For with our circumscribed faculties, we are constrained to submit to sequence in all subjects which engross our attention, even although it should be a description of the earth rising, at the command of the Great Creator, from beneath the water which so long had encompassed it; and, by one vast effort, sending forth enormous mountain chains; scattering massive boulders and blocks; forming breccias and conglomerates; engendering

fusion by inconceivable heat of friction; causing the deposition of extended areas of strata mechanically formed; and giving birth to an irresistible rush of water from the poles towards the equator; almost all synchronous, or during the first two days of the Mosaic week.

If the positions which we have assumed be correct, the deductions hitherto drawn be exact, and the mechanical laws have been properly applied, we should be able to deduce therefrom, that very important transformations necessarily took place in the form and surface of the spherical non-rotating earth, covered, as it was by a circumfluent ocean, when it was first caused to revolve around its axis.

Hitherto it has been customary to consider that the earth assumed its oblate form, or that which corresponds to rotation, while it was yet in such a state of fluidity as admitted of perfect mobility amongst its particles; and thereby became, as is usually expressed, "flattened at the poles, and protuberant in the equatorial regions."* These assertions, however, can be admitted as perfectly correct, provided only that a clear line of distinction be drawn between the *Aqueous* and the *Mineral* portions of the earth. In the former there was a flattening at the poles; in the latter *there was none.* Indeed, one of the most essential dogmas by which the present theory is distinguished from all others, and by which its truth is hereafter to be tested, consists in the fact, *that with respect to the solid materials of the earth, there was no flattening at the poles.* This *diameter* of the globe (for there were then no poles), is considered to have remained—as far as the *solid materials are concerned*—the same as when the earth existed in a spherical form before it was impressed with rotation; *the change in diameters, from those of a sphere to its actual spheroidal dimensions, having been effected by a decrease in the aqueous portion at the poles, and an enlargement of the surface and general diameter in both the solid and aqueous portions around the equatorial regions.*

In order more thoroughly and perfectly to comprehend,

* Astronomy, by Sir John Herschel; Connexion of the Sciences, by Mrs. Somerville; and others.

what we purpose to state respecting the results which proceeded more immediately from the earth's protorotation, there must beforehand be taken into account, those which would arise from two very distinctly constituted spheres being put into rotatory motion by the same force, namely, one sphere composed of solid mattèr, and another, a hollow one, of water; both containing a determinate quantity of matter, the latter being borne on the surface of the former.

When reasoning with respect to these we may, at once, dispose of the liquid hollow sphere, by conceding what actually took place, namely, that a sudden conflux of its water, from the poles towards the equator, caused this moveable hollow sphere to become flattened at the poles, and protuberant at the equator, by a transfer of its particles from one part to another, in order to complete that perfect form of equilibrium which the ocean alone presents; while it is to be remembered, that it was enabled to do this merely because the molecules of its mass were so constituted, with regard to each other, as to admit of perfect mobility in all directions, and thereby of their arranging themselves, when the entire mass was accommodating itself to the new form of rotation, so as to adopt a level surface throughout its whole extent.*

The concession of this point produces spontaneously the following two interesting conclusions:—1st. That the water was then under the same laws as at present, of which more hereafter; and 2ndly. That had the portions of the earth, now solid, been then in such a state of fluidity, either from aqueous solution or from igneous fusion, as would have admitted of their assuming an oblate form by a transfer of particles, or of becoming in the same manner flattened at the poles, with a corresponding protuberance at the equator, they, likewise, would, in obedience to the laws affecting fluid bodies in revolution, have assumed, at the same time, *a perfectly level surface*, similar to that adopted by the hollow sphere of water which we have just been contemplating; for they were both subjected to the same centrifugal force in quality and degree. Under these circumstances we can recognise no reason why the

* In accordance with what is stated in the 89th Theorem.

mineral portion of the earth should be supposed to have been possessed of sufficient fluidity to admit of its having assumed the spheroidal dimensions by a flattening at the poles, and corresponding protuberance at the equator, while we deny it the adoption of the other consequences which would inevitably have followed from the same degree of fluidity. It is of the utmost importance to be consistent in our opinions, and we shall therefore quote what has been said by scientific writers on the subject we are treating of. In the Cabinet Cyclopædia it is stated—

"Indeed, this theorem" (proving the tendency of water to assume and maintain its level) "is nothing more than a manifestation of the tendency of the component parts of every body to fall into the lowest position which the nature of their mutual connexion, and the circumstances in which they are placed, admit. Mountains do not sink and press up the adjacent valleys, because the strong cohesive principle which binds together the constituent particles of their masses, and those of the earth beneath them, is opposed to the force of their gravity, and is much more powerful; but if this cohesion were dissolved, these great elevations would sink from their lofty eminences, and the intervening valleys would in their turn rise—an interchange of form taking place; and this undulation would continue until the whole mass would attain a state of rest, when no inequality of height would remain. All the inequalities, therefore, observable in the surface of land, are owing to the predominance of the cohesive over the gravitative principle; the former depriving the earth of the power of transmitting, equally in every direction, the pressure produced by the latter."*

Whoever, therefore, maintains that the important transformation alluded to occurred while the globe was fluid, will have still to explain, according to his own hypothesis, why the mineral portion did not adopt a perfectly level surface, and undergo a change *from a level sphere to a level spheroid.* That this did not take place was fortunately and providentially ordained otherwise; and we must therefore look to some other source, for a more correct and comprehensive elucidation of

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* Treatise on Hydrostatics, Cab. Cyc. pp. 57, 58.

the cause whereby it is so differently constituted in its two important elements—land and water.

In doing this we shall commence by assuming the following limiting positions:—1st. That there was not a *transfer of solid material* from the polar to the equatorial regions, when the change of the earth's form took place, sufficient to effect its transformation into that of equilibrium;* and 2ndly. That assuredly there *was* an enlargement of the equatorial surface, and its general diameter;† which two limiting assumptions force us into the conclusion, *That only such a transformation of the surface occured as served to fulfil the conditions of the new state to which it was subjected when caused to rotate.* As the only change in the form of a spherical body, to which no addition from the polar extremities is made during the process, while an actual enlargement of surface ensues, is that *which transforms it into ridges and corresponding hollows*, it therefore results, that one of the most prominent effects of the centrifugal impetus upon the earth, constituted as we have supposed it would necessarily be, would transform its surface (enlarging it at the equatorial regions) *by the addition of material from within*, into immense continental ridges and oceanic hollows, whose direction would, in general, be in lines parallel to the axis of rotation, modified by a variation in the intensity of the elevating force, occasioned by the form of the revolving body; and whose elevations and depressions would increase in proportion as they approached the equatorial regions.

That this is the form which its surface has assumed, we shall

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* When we say "there was not a transfer of solid material took place," we do not mean these terms to be an unqualified negative; for we shall have to show, in the sequel of this discourse, that there was a vast quantity of loose material borne by the conflux of the water from the poles to the equator, which *filled up the rude and deep acclivities of these regions.* But this did not in any manner contribute *to produce the outline form of equilibrium,* although it served to round it off, and render it more productive and habitable. It is in this latter sense merely, that of the general outline, that the expressions above used are designed to be negative.—Author.

† We are obliged to use these qualified expressions from the belief, that there are parts of the earth's equatorial regions now covered by the ocean, which, if estimated from the solid surface of the antipodes, would, perhaps, be found to measure less than the polar diameter.

call in the aid of the *eleventh* Theorem satisfactorily to prove. It is therein stated, "*That on taking a general view of the great geographical outlines of the world, it is seen to be divided, in directions nearly parallel to its axis of rotation, into three great continental ridges, namely, that of North and South America, with the intervening archiepelago; 2nd, Europe and Africa; and 3rd, Asia and New Holland, with the Polynesia, which intervene. That there is a remarkable similitude in the general contour of these three great divisions, especially between the first and the last, seeming to indicate that their form is due to a common cause. And that within the equatorial zone are situated the most extensive table lands, and the greatest number of islands.*" While we refer to any geographical map for the correctness of what is stated in that Theorem.

Besides the evidences arising from the *outline form* of the great continental ridges, there are likewise satisfactory proofs discoverable in favour of this part of the dynamical theory, in the relative position of the component rocky masses themselves, as will be seen by perusing the *twenty-eighth* Theorem, which states, "*That it is not only the greater geographical height of the inter-tropical mountains which denotes the presence of a comparatively increased force in the regions where they are elevated, but their geological structure corroborates the same assumption. For, ' rocks similar to those which constitute the ridge of Jura in the Alps, are found to occupy the plains of England; and basalts which repose on the granites of the Andes are discoverable beneath the limestone of Skye.*' "*

On a retrospective view of what has been said with regard to the change which took place "in the twinkling of an eye," as it were, in the form of the earth, from a non-rotating sphere to a spheroid of rotation, perhaps no evidence could be adduced which militates more against the conceptions, hitherto entertained, of its having assumed the oblate form while in a fluid state, than the circumstance of there actually having been two spheres, the one fluid, the other rigid, superimposed on each other, and subjected simultaneously to the same impetus. For this remarkable coincidence leaves the theories, which are

* Geology, by Dr. M'Culloch, vol. i. p. 8.

formed on the supposition of fluidity, without the shadow of a foundation; it brings them to the touchstone at once, and reveals their unsoundness, by furnishing us with an example in which one of the spheres being fluid, in accommodating itself to the change, has not adopted a surface of undulating elevations and depressions, but moving on the face of the more rigid mineral sphere, has arranged itself in perfect horizontality: and unless it can be proved (but what no one will ever attempt to do), that the impelling force applied to the aqueous portion was different from what was exerted on the mineral mass, we must look to some other source for the cause of the differences of form and surface which, under similar circumstances, they have assumed; a difference only to be accounted for by admitting what was in reality the case, that the one was liquid, and obeyed the laws which govern matter in that state, while the other was so far rigid, that although the cohesion among its parts was overcome to a certain extent by the centrifugal impetus, yet it impeded the transmission of sufficient mineral matter from the poles to the equator to *fill up the perfect form of rotation, and to round it off into a revolving spheroid of level surface.*

A few moments of reflection will convince any one that the diversity observed by these two spheres—the outer pliant and moving like an elastic ring upon the other, while the mineral one remained invariable in polar diameter—was wisely ordained by the Creator, in order to form those open cavities, or hollows, destined to confine the water when "it rushed forth as from the womb," and to separate it from "the dry land;" likewise to adorn the earth with that charming diversity of land and ocean, hill and dale, river and lake, which render it so fit an abode for those creatures for whom it was prepared. The theatre, alas! of all their ingratitude for the wisdom, goodness, and power which were lavished in preparing it for them!

During the whole course of our reading we have never met with any attempt, to explain the origin of the continental ridges and oceanic hollows into which the earth's surface is so prominently undulated. These appear either to have been looked upon as necessary parts in the form of a world, or to be entirely beyond the limits of geology. Whether they

should form a part of that pleasing and instructive study we shall not at present stop to enquire; but we certainly think they should not have been overlooked in any treatise having for its object to account for the formation of the earth. They are very prominent features on its surface, and should therefore occupy a corresponding place in all cosmographical treatises; while we may very safely venture to affirm, that they *could not be in existence without having had an adequate cause.* We offer this explanation, therefore, to our readers, as an additional feature in favour of the dynamical theory, which not only does not shrink from nor overlook them, but would not be true if these immense elevations and cavities *did not exist. They are the necessary consequences, of the earth having been caused to rotate,* AFTER *the greater part of its stratified material had been deposited in concentric layers upon its submarine surface, and of the existence of the watery envelope which everywhere surrounded the non-rotating sphere.*

It is likewise presumed that the prevalences of islands within the equatorial zone, as noticed in the *eleventh* Theorem, is another proof of the correctness of the dynamical theory. Islands are the apici of submerged mountains, and evince at one and the same time the increase of the centrifugal impetus in those regions, and conflux of the water thither from the poles. Behold the wisdom and the goodness of this binary arrangement! Had the former not taken place with sufficient force to have thrown up these mountains, the equatorial portion of the globe would have been an unbroken, wearisome waste of water—a liquid, unproductive zone! On the other hand, had the latter been wanting, it would have been a rugged and impassable girdle of arid mountains. But by the manifold wisdom of the Creator, and the fitness of his arrangements, it is not lost to usefulness, either by the one extreme or the other, their harmonious combination rendering it easy of access, fruitful in soil, and salubrious in climate, from the mitigated rays of the tropical sun by the abounding water, which likewise facilitates the communication from zone to zone, and from hemisphere to hemisphere.

It must have appeared obvious to the reader, by what has hitherto been said, with respect to the great continental ridges,

that they have been treated of in general terms, and presented to the view as mere outlines—a rude mineral skeleton of towering peaks and sharp acclivities, such as might be conceived to arise, when one mass of bare rock was caused to perforate another by the violence of the centrifugal impetus, but not yet filled up, or rounded off, by the deposition of the immense mass of *debris* spoken of in the *thirty-second* Theorem. The process by which this transformation was effected, and this part of the earth became a fitter habitation for man and the terrestrial animals, will be fully explained when we close in upon the subject, and treat it in a more definite manner, with reference to stratified masses superimposed on the unstratified ones in a determinate order, subjected alike to a force of known rate and direction, capable of dislodging both from their recumbent posture. Then it will be recognised, that there was a mass of debris spread abroad, which can only be accounted for by supposing that it went to fill up rocky hollows such as we have been contemplating; while it will be our care to explain how great a proportion of it was swept by the rush of the polar water to the equatorial regions, and being there spread abroad upon its rugged and rocky surface, how it conduced to round it off, and to render it more habitable.

In further confirmation of this view of the case we would, without going into particulars, which we shall have to do presently, generally observe, that *denudation* is a geological feature, which writers in that science have occasion to insist much upon, when they are describing formations in high and even moderate latitudes, such as those of our own country, MM. de la Beche's, Phillips's, and Lyell's respective works abounding with passages descriptive of the effects of denudation by water; when the same writers, however, have to direct the attention of those whom they are instructing to the regions within the tropics, and near to the equator, they require to bring forward evidences of vast accumulations of water-borne stratified material which have filled up hollows and rounded off sharp acclivities amongst widely extended table lands. For example, the description given by the former,* from the writings

* Manual of Geology, pp. 409—412.

of Humboldt, of those of Mexico and New Grenada, and the more recent and admirable description, by Mr. Lyell, of the valley of the Mississippi, all of which, and especially the contrast which they present, between the leading developments of these two divergent regions of geological research, are precisely in keeping with what we had reason to expect as the effects of the centrifugal impetus and the rush of water from the poles towards the equator, which took place on the protorotation of the earth; while the denudation in the higher latitudes, and the corresponding deposits in the tropical regions, afford the most conclusive evidence *that the waters did not return;* but having carried their earthy load and deposited it where they came to rest, by assuming their static form of rotation, they were there constrained for ever afterwards to remain, and to produce those desirable and needful effects to which we alluded above. It should be noticed, at the same time, that this result would be accomplished by a transference of waters from the polar extremities in quantity corresponding to a depth of about $6\frac{1}{2}$ miles, or half the excess of equatorial radii over those corresponding to the earth's other two semi-diameters.

We confess ourselves incapable of determining, by reasoning *a priori,* whether the number of three great outline ridges—into which the earth is divided—be that into which a world such as ours in dimensions, geological structure, and impelled by an angular velocity of 15° per hour, ought, from secondary causes, to have been broken up. This interesting problem may probably form the subject of future investigations, and we doubt not, as we have already surmised, *but that it will then be found to have been the result of secondary causes.* We are convinced, that all things were previously disposed so as to enable the terraqueous globe to assume its present tripartite continental divisions, with their respective accompaniments, as the necessary results of secondary causes, themselves the effects of immediate causes emanating from the Omnipotent Creator of all, " without whom was not anything made that is created and made."

Proceeding with our argument we must remind the reader, that in a former part of this section it was laid down as an ascertained data, that the consecutive layers of rock which formed

the outer crust of the non-rotating sub-marine earth, *increased in density as they receded from the surface.* Also, that the distance of the upper and under surfaces of the stratified envelope might, for all practical purposes, be considered equidistant from the centre of gyration. To the geological phenomena, circumstanced as we have thus stated, we shall now endeavour to apply the last clause of the *seventy-third* Theorem, wherein it is asserted "*That all other circumstances being equal, 'the centrifugal force increases as the mass of the moving body increases.'*"

If we conceive the deposited strata, at the bottom of the original ocean, to have been lying horizontally, in a determinate order of superposition, at the time when the above law was brought into exercise by the rotation of the earth around its axis, whereby centrifugal impetus was impressed alike upon all the rocky masses of its terraine crust; it will appear obvious that, when they started from their recumbent postures to assume their respective places in the new order of things which was to follow, when the transformation from a sphere to a speroid took place; the heaviest—all other circumstances being equal—would be caused to fly farthest from the centre of gyration, "the centrifugal force increasing as the *mass* of the moving body increases."

From what has already been explained, we have seen that the *undermost* were the *heaviest;* consequently, in obeying the new law thus impressed upon them, they might either have perforated the stratified rocks above, and thrust their rugged and pointed summits, in towering grandeur, above all around them: the superincumbent stratifications, from being also impressed with centrifugal impetus, and possessing considerable molecular cohesion, might have resisted the perforating action of the inferior masses, and the whole group have swelled out into a mountain form, with summits capped by stratified material, in disjointed massive blocks suitable to the enlargement of superfice which together they had undergone; or, lastly, a modification of these extreme cases might have taken place, and the unstratified rocks, while they partially perforated the strata, might have forced other parts of them into elevations along with themselves, assisted by the centrifugal impetus im-

parted to the accompanying strata; in which case, the apici of the mountain would consist of amorphous rock, presenting high pointed peaks, with shoulders and flanks, composed of those stratified materials which accompanied the nucleii to a certain extent in their rise from horizontality. And, finally, as the strata were elevated by the impetus of underlying masses, which, in moving from below upwards, assumed a pyramidal form, they would be raised to the greatest elevations, and into positions approaching nearer to verticality in proportion to the priority of their deposition, or their inferiority in the order of stratification.

According to these views it is obvious, that diversified effects would ensue from the application of the centrifugal force to a sphere of such complex structure. The continental elevations and oceanic hollows, together with the general form of equilibrium, may be considered as the principal results—the greatest change of relative position to which its rocky masses were subjected. Mountains and valleys, more dependant on the nature of the masses immediately overlying each other, and on their latitudinal situation, would be brought forth indiscriminately on the surface of continents, or on that of the ocean beds; while these, in turn, would become studded over with lesser inequalities, from the unequal densities of their component elements, and other influences of a more local character. Thus we have one general cause, *the first rotation of the earth around its axis*, modified by the nature and situation of the materials on which it was made to act, employed by the hand of the Creator, in a moment of time, to change that which was "without form and void" into a world of infinite variety of surface, admirably adapted to fulfil the chief design of its creation: a richly adorned pedestal on which myriads of creatures, of widely diversified habits, are nurtured and reproduced in almost endless succession, "each after his kind," and designed to glorify him, who, in wondrous wisdom, made them all; while they are wheeled so smoothly through space as to have required the intellectual labours of generations of astronomers, to convince the human race, that the planet they inhabit is not absolutely immovable in the clear blue vault of heaven. And now, most probably, it may prove as arduous an undertaking

to convince their descendants, that what their forefathers wrongfully maintained as an immutable law of the system, even to the persecution of those who asserted to the contrary, *was once actually the case*, and that the revolving globe, on which they stand, has passed through a period of non-rotation so protracted as to warrant the surmise, that it may have exceeded even that of its known diurnal motion.

END OF THE FIRST VOLUME.

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